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SOVIET SOIL SCIENCE

10

OCTOBER 1960

A TRANSLATION
OF POCHVOVEDENIYE

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The translation and publication of this and other Russian language biological journals and monographs is a project of the American Institute of Biological Sciences. This project is supported by grants from the National Science Foundation. Each publication is a cover-to-cover translation of its Soviet counterpart and the contents are only those of the original authors.

Pochvovedeniye in English translation bears the Soviet issue numbers. The Soviet journal carries no volume numbers. Translation begins with Number 1, the January 1958 issue. It is published in the same number of issues per year as the original Soviet journals: 12 issues.

translated and produced by
ROYER & ROGER, INC.
INTERNATIONAL DIVISION

Subscription Prices:

$40.00	per year, individuals and industrial libraries
20.00	per year, university and non-profit libraries
3.00	additional to each price for foreign orders
4.50	each, single copies

Order from:

American Institute of Biological Sciences
2000 P Street, N.W., Washington 6, D.C.

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SOVIET SOIL SCIENCE

*A translation of the monthly journal—POCHVOVEDENIYE—
a publication of the V. V. Dokuchayev Institute of Soil Science,
Academy of Sciences, USSR. A journal founded in 1899.*

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o. 10: October 1960 Translation printed: October 1961

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LITHOGENIC SOIL COMPLEXES IN THE SOUTHEASTERN PART OF THE KAZAKH LOW-HILL PLAIN

A. A. SOKOLOV and N. I. KOTIN, Soil Science Institute, Academy of Sciences, Kazakh SSR

Most of those who investigated soil-vegetation complexes (2, 4, 5, 6, 7) relate the formation of soil complexes to the effects of microrelief. This relief, which formed as a result of various causes, creates differences in the moisture regime of neighboring areas, which under arid climatic conditions determines corresponding variations in vegetation and soils depending on the degree of their salinizaton, solonetzization, etc.

Some scientists believe that lithologic conditions play an important part in the process of formation of the complexes. Thus, Bezsonov (1) explained the origin of the complexity of the Caspian Lowland by the fact that this area is landlocked and also by the differences in soil materials, parent materials and the degree of their salinization. Tsatsenkin (8) believed that in certain cases (the Kulmyk steppes) complexes exist because of a diversity of parent material. Vostokova (3), who studied the Aktyubinsk Ural area, noted the influence of the underlying material on vegetation complexes. However, all of this material is too general and insufficient for determining the effects of soil and soil material of varying lithologic composition on the formation of soil-vegetation complexes.

While studying the soil of the southeastern part of the Kazakh low-hill plain and also in desert and desert-steppe areas on the left bank of the Irtysh River, the authors of this article found that two-layered soils and soil materials were widely distributed. In the large areas between the hills, and in mountain and piedmont valleys soil forms on relatively thin parent material of rubbly and gravelly clay loam underlain by more or less thick deposits of rubble and gravel.[1] Because of the presence of ground water at a shallow depth and the varying thickness of the upper clay loam layer, this two-layered structure of soil and soil material leads to the formation in places of soil complexes which could be called lithogenic.

To characterize the lithogenic type of soil complex, a schematic representation of a more or less typical key area is shown in Figure 1. This area is located 32 km to the northwest of Abay village (former Kara-Aul) and 4 km to the south-southwest of Lake Opankol' at the border of a large depression near the lake where the border changes into the gentle slope of the adjoining valley between hills with shallow light-chestnut soils developed on two-layered deposits.

The three-fold complex of this area is formed by meadow-steppe solonchak-like solonetzes under wormwood-saltbush vegetation, solonetz-solonchaks under halophytic vegetation and light meadow-chestnut solonetzic soils under wormwood-feathergrass-steppe grass vegetation. It is significant that there is no regular pattern of any sort between the distribution of individual components of the complex and the microrelief. While the components of the soil-vegetation complex stretch mainly in the latitudinal direction (apparently in the direction of ancient streams), the prevailing direction of the individual microrelief elements is longitudinal (primarily in the direction of a slight recent tilt toward the middle of the lake depression). In general, however, the microrelief is poorly defined, varying in relative elevation from 10-20 cm (up to 50 cm). The strongly mineralized ground water lies at a depth of 100-150 cm. The aquifer consists of more or less thick deposits of slightly rounded gravel.

For a more detailed characterization of the complex under study, morphological descriptions of soil profiles forming the complex are given below, as well as their analyses (Tables 1, 2, 3).

Profile 215. Meadow-like chestnut, light, slightly solonetzic, thin medium clay loam, underlain by ancient sandy-gravelly alluvium at a depth of 45 (26) cm. Vegetation consists of feathergrass, sheep's fescue, koeleria, steppe sedge, sea and black wormwood, and pale-green lichen. The vegetation density is 40%-50%. The soil effervesces from HCl at a depth of 7 cm. Salt efflorescences were found (September 30, 1958) on the dried walls of the trench below 85 cm. Ground water with a salty taste was found at depths of 100 cm (July 1) and 120 cm (September 30).

0-10 cm. Grayish-brown, dry, compacted, cloddy to powdery, coarse-sandy-medium clay loam.

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[1] Thick layers of slightly-rounded gravel have apparently formed during the more humid glacial period, while the deposition of rubbly clay loam occurred during the xerothermal post-glacial period.

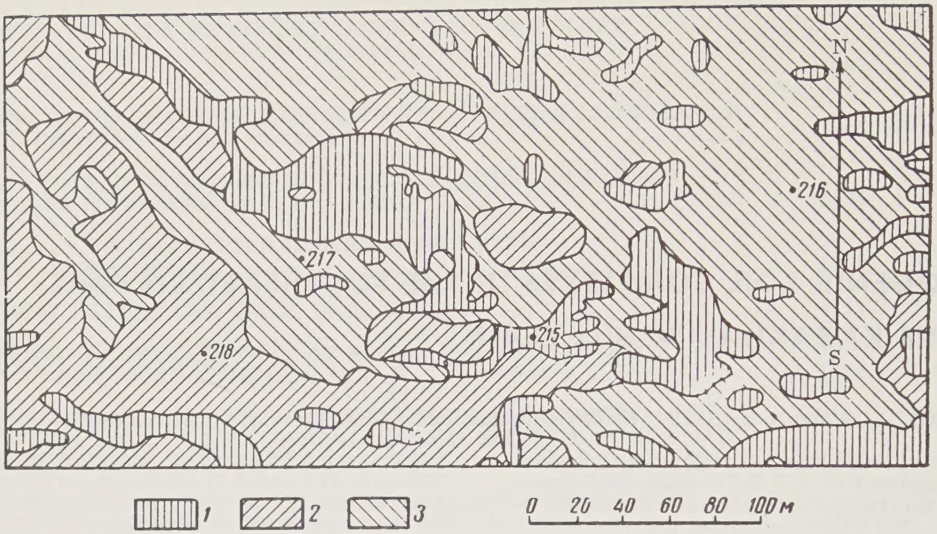

Fig. 1. - Schematic plan of a lithogenic complex.

1 - meadow-like chestnut slightly-solonetzic soils under wormwood-feathergrass-steppe grass vegetation; 2 - meadow-steppe solonchak-like solonetzes under wormwood-saltbush vegetation; 3 - solonetz-solonchaks under saltwort-saltbush-Camphorosma vegetation.

Table 1

Particle-size composition of soil from a lithogenic complex, in % of dry soil (Analyzed by Yu. N. Zhdanova)

Profile No.	Depth, cm	Hygroscopic moisture	Loss from treatment with HCl	Diameter of fractions, mm								<0,01	
		In %		>3	3—1	1,0—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,001	Not counting losses	Counting losses
215	0—7	1,8	3,9	7,1	11,0	23,4	15,1	10,5	7,1	13,5	15,5	36,1	37,8
	10—15	1,6	11,4	8,7	17,0	16,5	7,2	9,4	5,7	10,7	22,1	38,5	43,4
	21—26	2,4	12,2	23,0	24,0	18,3	8,2	7,3	3,2	5,0	21,8	30,0	35,2
218	0—4	1,0	1,0	8,4	22,0	16,2	22,5	16,8	7,8	7,7	6,0	21,5	21,9
	4—10	1,8	11,5	7,4	17,0	13,4	7,3	14,0	3,7	7,0	26,1	36,8	41,7
	20—25	2,6	22,1	4,1	10,0	10,5	4,7	18,3	3,2	5,1	26,1	34,4	43,9
	60—70	3,4	17,5	0,5	5,6	2,1	6,5	27,7	10,2	4,9	25,5	40,6	48,1
217	0—10	1,0	6,5	Not det'd.		28,2	20,2	13,0	9,0	9,3	13,8	32,1	35,4
	30—40	2,6	21,0	"		12,7	13,6	13,2	3,3	1,6	34,6	39,5	50,0

Note: Comma represents decimal point.

10-26 cm. Darkish-brown, dry, compact blocky, sandy-medium clay loam with pebbles.

26-45 cm. Grayish-brown with white carbonate spots, dry, compact, sandy light clay loamy with lenses of coarse sand and pebbles.

45-85 cm. Gray, dry coarse-sandy — finely gravelly.

85-150 cm. Same as the previous layer, but moist and with salt efflorescences on the dried walls of the trench.

Profile 218. Meadow-steppe solonchak-like, crusty medium clay loam solonetz on ancient sandy-gravelly alluvium below 90 cm. Vegetation consists of saltbush, pale-green lichen; black, solonchak and Shrenk wormwood (not so

Table 2

Chemical and physical-chemical composition of a lithogenic complex (Analyzed by M. B. Varshavskaya, I. S. Mezhenina, U. Sultanbayeva and T. P. Turchaninova).

rofile No.	Depth, cm	Humus	CO_2	Adsorbed cations, meq per 100 gm of soil					pH
		In %		Ca^{++}	Mg^{++}	Na^+	K^+	Total	
15	0—7	3,9	—	20,4	None	0,2	0,8	21,4	7,8
	10—15	3,3	3,8	16,6	1,8	0,1	0,5	19,3	8,0
	21—26	3,6	5,0	18,5	9,3	0,2	0,4	28,4	8,0
	70—80	—	1,8	—	—	—	—	—	—
	90—100	—	1,6	—	—	—	—	—	8,8
18	0—4	2,1	—	7,6	4,7	0,7	0,7	13,7	8,0
	4—10	2,3	—	8,5	4,0	4,0	0,2	16,7	8,0
	20—25	1,0	7,6	2,5	5,4	5,4	0,1	13,4	8,2
	60—70	—	5,0	—	—	—	—	—	8,5
	95—105	—	—	—	—	—	—	—	8,3
	125—135	—	—	—	—	—	—	—	8,0
17	0—10	1,1	1,2	—	—	—	—	—	8,0
	30—40	0,7	5,7	—	—	—	—	—	8,2
	90—100	—	2,2	—	—	—	—	—	8,2

te: Comma represents decimal point.

Table 3

Content of water-soluble salts in the soils of the lithogenic complex in % of air dry soil (Analyzed by I. I. Yegorova and P. I. Pushkina)

rofile No.	Depth, cm	Solid residue	Alkalinity		Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+ (by difference)
			HCO_3^-	$CO_3^=$					
15	0—7	0,103	0,029	None	0,008	None	0,006	0,002	0,005
	10—15	0,092	0,034	"	0,011	"	0,008	0,001	0,009
	21—26	0,034	0,039	"	0,001	"	0,003	0,002	0,002
	90—100	0,202	0,020	"	0,039	0,061	0,002	0,003	0,054
round water at 20 cm		41,936[a] —	0,300 0,4	0,06 0,0	11,485 26,0	14,047 23,6	0,551 2,2	1,828 12,2	10,147 35,6
18	0—4	0,068	0,027	None	0,003		None		0,012
	4—10	0,240	0,103	"	0,013	0,004	0,004	None	0,044
	20—25	1,210	0,029	"	0,068	0,698	0,094	0,015	0,253
	60—70	1,364	0,024	"	0,647	0,131	0,013	0,019	0,440
	95—105	0,551	0,010	"	0,076	0,261	0,075	0,013	0,067
	125—135	0,518	0,007	"	0,093	0,218	0,072	0,011	0,064
ound water at 50 cm		76,540a —	0,133 0,1	"	36,821 46,4	3,750 3,5	1,967 4,4	3,824 14,2	16,111 31,4
17	0—10	0,450	0,133	0,002	0,005	0,174	0,002	0,003	0,128
	30—40	1,654	0,029	None	0,016	1,046	0,047	0,015	0,440
	90—100	0,330	0,034	"	0,071	0,113	0,002	0,003	0,105
ound water at 20 cm		73,804 —	0,559 0,6	"	17,962 30,7	14,905 16,7	0,505 1,5	2,658 13,4	13,329 35,1

[a] Numerator — g per liter; Denominator — percent-equivalents.

Note: Comma represents decimal point.

abundant); occasional Statice shrubs, fescue grass, prostrate knotweed, fragile rye, rock rye. The vegetation density is 30%-40%. The soil effervesces from HCl at a depth of 15 cm. Salts (September 30, 1958) are found at a depth of 13-28 cm in the form of fine crystalline accumulations, at 28-90 cm, in the form of small veins and sparkles. No salt was detected on the surface of the freshly-dug profile at a depth of 90-150 cm. Weak (90-115 cm), medium (115-135 cm), and strong (below 135 cm) salt efflorescences were found on dried walls. Ground water with a salty taste was found at depths of 120 cm (July 1) and 150 cm (September 30).

0-4 cm. Brownish-light gray, dry, slightly compacted, porous, layered, sandy coarse clay loam.

4-15 cm. Dark-brown, dry, compact, prismatic-nutty, sandy-medium clay loam with gravel.

15-28 cm. Reddish-brown, slightly moist, compacted, sandy fine clay loam with gravel.

28-90 cm. Grayish-brown, slightly moist, compacted, sandy fine clay loam with gravel.

90-135 cm. Gray, moist, fine gravelly.

135-160 cm. Brownish-gray, wet, clay.

Profile 217. Fine clay loam solonetz-solonchak on ancient sandy-gravelly alluvium below 70 cm. Vegetation consists of camphorosma, saltbush, saltwort, shrenk and solonchak wormwood, calidium, statice shrubs, Anabasis, etc. The vegetation density is 40%-50%. Effervesces from HCl from the surface. Salts were found (September 30, 1958) at a depth of 0-70 cm in the form of small white veins and spots and deeper on dried walls of sandy layers in the form of white and sometimes swollen surface efflorescences. Ground water with a salty taste was found at depths of 96 cm (July 1) and 120 cm (September 30).

0-16 cm. Brownish-gray, damp, loose, sandy-medium clay loam with fine gravel.

16-40 cm. Reddish-brown with whitish carbonate spots, moist, structureless, sandy fine clay loam with fine gravel.

40-70 cm. Grayish-brown, moist, sandy fine clay loam with fine gravel.

70-130 cm. Grayish-brown, damp at the top and moist and wet with depth, salinized, layered on a slant, sandy gravelly with many interlayers of sand.

The results of the analyses (Tables 1 and 2) corroborate our description and genetic determination of the soils. Only the fine earths of the horizons were subjected to a particle-size analysis (sandy-gravelly deposits underlying the soil were not analyzed). Figure 2 gives a clearer picture of the distribution of strata of differing textures and of ground water.

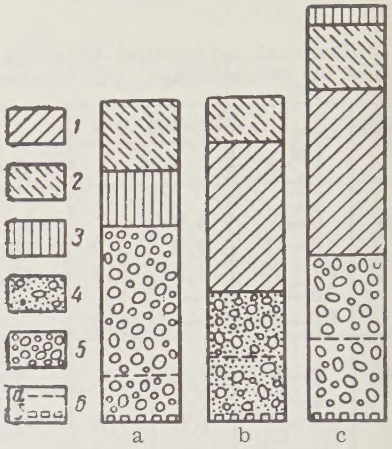

Fig. 2. - Lithologic profile of soil and soil material components of a lithogenic soil complex.

Clay loam: 1 - fine; 2 - medium; 3 - coarse; 4 - sandy-gravelly deposits; 5 - gravel; 6 - groundwater table: a) July 1, 1958; b) September 30, 1958. Profiles: A - 215; B - 217; C - 218.

An analysis of soil extracts (Table 3) shows that the gravel lying close to the surface (25-45 cm, Profile 215) completely prevents penetra tion of salts into the soil from the shallow (10 120 cm) highly-mineralized ground water. I this case soil forms under conditions close t zonal conditions. When ground water is locat at the same depth (100-120 cm), but the fine earths layer is thicker (70 cm) and the under lying material contains much sand (Profile 217), conditions are created for a more or less continuous capillary connection between the upper soil and ground water, as a result which the soil becomes greatly salinized. However, intense salinization of surface hori zons occurs, apparently, only periodically. This is why solonetz-solonchaks, with proper ties intermediate between solonetz and solon chak, form here. When the ground water is located more deeply (120-150 cm), a capillar connection between the surface and ground wa apparently becomes established only during s periods, even when the fine earth layer is mu thicker (90 cm, Profile 218). However, in th case an enrichment of the lower soil horizons with salts occurs. This leads to the formati of solonetz with vegetation similar in its com position to that of meadow-steppe solonchak-like solonetz. If the fine earths and soil materials had been uniform, typical soloncha would have developed here in all of the cases examined.

It is interesting to note that in spite of the fact that ground waters are located very clos to each other, they also show a certain heter geneity in their degree of mineralization and the composition of their mineral components. Under more salinized soils they are more m eralized and vice versa. The gradual concer tion of salts in the corresponding soils, whic thus serves as "wicks," leads to a gradual increase of the salinization of ground water.

trary, under soils in which ascending ry currents are absent, ground water we do not take into account diffusion oriented ground-water runoff) either its concentration or become diluted, ing on the nature of their recharge by heric water. Such a differentiation in inization of ground water, which is re- to a certain degree by the complexity salinization of soil, intensifies this com- .

complex area described previously was ed by us twice during the same field (July 1 and September 30, 1958). Un- tely, we did not have the opportunity to he changes in soil moisture and the of the salinization of soils in the sea- ycle (the soil was analyzed only during st period and ground water only during ond period). Nevertheless, on the basis e and other observations on complex sur- t may be stated that unusual lithogenic xes exist.

plex soil-vegetation formations of a nature can be found also when ground lie deep. Thus, in the valleys between the Kazakh low-hill plain, which consist layered deposits and have a completely flat without any signs of a microrelief, com- of light chestnut non-solonetzic soils ollen solonchaks may frequently be en- ed which are unusual at a first glance. examination reveals that the light chest- ls are meadow-chestnut clay loams under- a shallow depth by gravel and developing hallow (about 3-4 m) mineralized ground ocated in the gravel. Under such condi- olonchaks develop on more uniform ams which provide for the capillary ent of ground water toward the surface.

ilar soil-vegetation complexes can be und in other areas with shallow fresh water such as, for example, the flood of mountain rivers, piedmont valleys, this case, in addition to meadow soils, ing on more uniform deposits, meadow- ils (meadow-like-chestnut, meadow-like zem, meadow-like sierozem) may be en- ed which are closely underlain by gravel.

s, the initial causes of the complexity may be the lithological structure of soil l material and not only the characteris- microrelief. In the case of a two- soil and soil material (characterized by th upper horizon, such as clay loam, ance, and a gravelly lower horizon), a ound-water table, and variations in the ss of the upper fine earth horizon and epth of the lower gravelly horizon, soil s can either periodically or constantly he zone of the capillary rise of ground or lose any capillary contact with it. In se if the ground water is mineralized, soil-vegetation complexes may form at face consisting of non-saline and saline olonetzes and solonchaks), while in the e of fresh ground water the complexes m from non-saline soils, differing in egree of hydromorphism (for instance, , meadow-steppe, meadow-like steppe, er soils) and corresponding plant groups. In such a case there may be either no surface microrelief, or the microrelief may not correspond with the nature of the complexity.

Conclusions

1. Two-layered soil and soil material consisting of a thin gravelly clay loam at the surface underlain by slightly rounded gravel are widely distributed in the large valleys between hills in the southeastern part of the Kazakh low-hill plain. When salinized ground water is close to the surface and the thickness of upper clay loam layer varies, unusual soil-vegetation complexes form in places which may be called lithogenic.

2. The described lithogenic complexes consist of unusual meadow-like-chestnut, weakly solonetzic soils, meadow-steppe solonchak-like solonetzes and solonetz-solonchaks. The distribution of these components does not correspond to the microrelief, and is determined by the depth of which gravel occurs and the nature of the capillary connections between the soil horizons and the highly mineralized ground water.

3. Lithogenic complexes may also occur under other conditions, including over fresh ground water, provided that soil and soil materials are two-layered and that the water table is high.

4. Lithogenic complexes containing salinized soils can be reclaimed only if the water table is lowered.

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Received April 14, 1960

THE PHILOSOPHICAL FOUNDATION OF V. V. DOKUCHAYEV'S SCIENTIFIC WORK

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V. V. Dokuchayev's creative legacy has a great theoretical importance. It gives a basis for the development of individual philosophical problems in natural sciences. However, our literature has not devoted enough attention to this fact. Articles by Yakovleva (10), and Belova (1, 2) published in "Problems of Philosophy" and "Soil Science" were only the first steps in the discussion of individual problems. The author of the present article is making an attempt to show the philosophical aspect of Dokuchayev's scientific work.

Dokuchayev's materialistic view of nature is revealed whenever he examines and explains both individual bodies and phenomena, as well as nature as a whole. His premise was that nature had existed before living creatures including man, appeared, and before consciousness. The cornerstone of his philosophy was laid in his early works by the statement that "...both phenomena and bodies exist in nature completely independently from us" (3).

To him it was clear that all phenomena and bodies are products of nature itself and that for nature as a whole it did not matter whether its individual manifestations and processes are useful to man. Dokuchayev wrote that "Nature exists by itself, regardless of whether man is taking advantage of it or not. Therefore in nature there is no (and cannot be) phenomenon, or object, positively useful to positively harmful to us. The same can be said about gullies; they already existed when there was no man on earth and now they continue to live completely independently of him" (3). He emphasized that "...the soil, as any other natural body (a lizard, a butterfly, a pike, etc.), certainly would exist regardless of whether man should cultivate it or not" (8).

Dokuchayev believed that the quality properties of objects, including soil properties, exist objectively, outside of and independent of the consciousness of an observer. He stressed that "...the properties rooted primarily in the composition, structure, texture, and chemical composition of soils..., inherent to soils such as color, weight, and hardness, are inherent to soils as to all other bodies..." (7).

Dokuchayev's attention was also attracted by the problems of the unity and integrity of nature. To him the interrelation of bodies and phenomena was an evidence of the material basis of nature.

He wrote "The astonishingly majestic fact that all realms of nature — the animal and pla kingdoms, soil, in particular, and the minera kingdom, in general — consist of essentially same basic elements already known to ancien man, such as water, earth, air and fire (heat and light), with insignificant variations and su stitutions... in the individual realms, speaks of the closeness, integrity, and so to say, un of all living and existing things. These eleme and the foregoing kingdoms consist in their tu of only four to five elements, such as oxygen, hydrogen, carbon, and nitrogen, which are th primary building blocks, of water and air, plants and animals" (9).

Dokuchayev believed that all bodies and natural phenomena manifest themselves in sp and time. By the same token, soils, occupyi a definite geographic position, are subject to constant change. He wrote that soils"...are not only very variable values in space, but al in certain respects comparatively unstable in time. Actually, we do not know of any soil which has retained its given characteristics forever..." (6).

Dokuchayev's attention was also attracted the problem of diversity combined with unity. He tried to discover not only the nature and properties inherent to soil and distinguishing from other bodies, but also that which unites soil with other bodies. He pointed out that, even though soil is an individual natural phenomenon, it is inseparable from other bodies phenomena and obeys the same laws in its for tion and development. Dokuchayev stated tha "As any other natural body, soil has its past, its life and its genesis" (7).

Dokuchayev also correctly viewed the casu relationships. After pointing out that relatio of various natures exist between natural bodi and phenomena, he emphasized that internal lationships play the decisive role, since with them natural bodies could neither come into ing nor exist. At the same time the casual re lationship is the essential basis for the interaction between bodies and phenomena and the overlapping. He believed, in particular, tha the geographic distribution of plant species d pends on the combined effect of a number of

:ors, such as climate, relief, soil and its nomic utilization by man. In turn, Dokucha- believed that "Soils are a constantly chang- function of a) climate (water, temperature, gen, atmospheric carbon dioxide, etc.); b) ent materials; c) plant and animal organisms, ecially of the lower order; d) relief and vation; and, finally, e) soil and partially the geological age of the country" (7).

Dokuchayev believed that a direct necessity vails in nature which expresses itself in the ular manifestation of a given process. To it was clear that the main soil groups are tributed on the surface of the earth not at dom, but according to a law. Therefore s are not a mechanical lifeless mixture as n by archaeologists, but are independent ıral formations having their own causes and s of development, and a specific structure. always tried"...to see a law in nature and er lawlessness and chance." He believed the main objective of any investigation is discover "The casuality and, so to say, inner necessity of a given distribution of s" (3).

The correct understanding of the nature of ıral laws and of their importance is clearly ected in Dokuchayev's work, in his ex- nation of various processes. To Dokuchayev w was the expression of constantly effective lasting relations. He believed that only the help of laws can one understand and ex- n the character and direction of natural cesses, and reflect their integrity and unity. insisted that: "Now, at the turn of the 20th tury, it is high time that attention be paid to everlasting relationship — the always regu- genetic relationship which exists between ces, bodies, and phenomena, between dead living nature, between the plant, animal mineral realms..." (8).

He determined that "...soils, in their ribution, obey strict laws" (5). This is erned by natural conditions participating in creation of soil. "...since all major soil nation factors are distributed at the surface he earth in the form of belts, or zones, ex- ding more or less in a latitudinal direction, s (such as our chernozems, podzols, etc.) t also be zonally distributed at the surface he earth, in a strict dependence on climate, etation, etc." (8). Precisely on such a basis Dokuchayev create the science of soil and ıral zones, which has a tremendous theo- cal and practical importance today.

Dokuchayev established and formulated the s of soil science, which in their importance ch beyond the limits of their science and em- ce even larger fields of natural science. In e "zones of continuous interrelationships" expressed the principles of the relationship veen soil and factors and conditions of its nation, as well as the scientific understand- of the genesis of soils, their evolution, and ependent existence. These positions not only ot contradict, but are in harmony and in agreement with the basic principles of hurin's biology of the unity of organisms media. Dokuchayev points out that "... he hands of an experienced soil scientist, these positions and laws must greatly facilitate, simplify, and at the same time regulate soil investigations in general and especially evaluation studies" (7).

It is easy to understand the enormous philosophical importance of all investigations and theoretical conclusions to the progressive development of various fields of natural science. It is understandable that only on this general theoretical basis could Dokuchayev defend the ideas and principles not only of his science, but of progressive natural science and actively fight idealism and metaphysics in the concept of nature.

It should be kept in mind that at the time of Dokuchayev's activity, all official bourgeois and landlord sciences were in the power of idealism and religion. Natural sciences were taught in primary schools and institutions of higher learning with frequent references to "the wisdom of God and our limitations in the understanding of miracles surrounding us." The investigations and discoveries of Dokuchayev were contrary to such science in their objectivity and expressed a direct and resolute protest against idealism. They clearly showed the incompatibility of progressive science with religion.

Basing himself on the evolutionary theory in geology (actualism), Dokuchayev went against the idealistic theory of catastrophes, which was widely adopted in the West, as well as in Russia. Before Dokuchayev, the origin of river valleys was explained exclusively by catastrophic processes. Buffon, Werner, and Cuvier in the West believed that river valleys formed as a result of the rapid lifting and submergence of individual areas of the earth's surface along which draining waters and floating detritus formed valleys. The causes for these phenomena they sought outside nature, in Divinity. These theories, which were closely related to the legend of the Deluge in the Bible, could not give a scientific explanation of this natural phenomenon.

In Russia the idea of catastrophes was propagated and used by Gel'mersen, Kutorg, Ber, Golovkinskiy, Levakovskiy, and others to explain certain geological phenomena.

In dealing with geology, Dokuchayev set himself as a goal to discover the natural causes and laws of the formation of river valleys. In order to prove his point he selected the plains of the earth for his observations and investigations of this phenomenon. He determined that river valleys form and develop under in the influence of streams of water and the fluctuations of the lithosphere. Dokuchayev noticed that the flood plains of most rivers have areas which widen in a similar manner as lakes do and alternate with areas in which the original banks draw together. This lead him to the important conclusion that the majority of rivers investigated by him formed as a result of the confluence of past lakes through gullies. The formation of river valleys was believed by V. V. Dokuchayev to be a long process consisting of individual interrelated links, expressing both the continuity and the discontinuity of the natural course of development. He wrote that"...river valleys, which are now tens of sazhens deep and several versts wide did not form suddenly; there was a time when the river bed began to form. . . " (7). In his work "Processes of river valley formation in European Russia" (1878) Dokuchayev developed not only a classical theory of the formation of river valleys, but denied catastrophism in geological phenomena.

A prominent place in Dokuchayev's work is occupied by the problems of the theory of cognition. The problem of the cognition of the world found its reflection in his scientific studies. This scientist not only defended the principles of the materialistic theory, but advanced and worked out its individual aspects. The general principles used by Dokuchayev were: a) the acceptance that the object of study is external nature, independent of the consciousness of man, its bodies and phenomena; b) attempt to look at cognition as a complicated process, composed of several steps; c) the attempt to give the correct solution to the problem of the unity of theory and experience; d) the tendency to go beyond the limits of the contemplative view on nature, and the recognition of the necessity for man to interfere with nature on the basis of scientifically established laws in order to change it. He defended methods of study which were proved by practice, and demanded the comprehensive, and full examination of the object under study.

Dokuchayev clearly saw that the main drawback of the natural sciences of his time, which were limited by metasphysics, was the fact that "Individual bodies, such as minerals, rock, plants and animals, and phenomena were primarily studied, as well as individual elements, such as fire (volcanism), water, earth, and air, in which science reached great results, but not their interrelationships — this genetic, everlasting, and always regular relation which exists between forces, bodies, and phenomena and between dead and living nature. . . " (7).

In his practical investigations and theoretical generalization Dokuchayev came ever closer to the scientific understanding of individual aspects of the process of cognition. Basing himself on facts and observations he strove toward the clarification of the interrelationship and interdependence between bodies and phenomena, toward the understanding of the relationship between them. He believed that "precisely the clarification of these relationships is the essence of any truly scientific investigation and the greatest pleasure of any science. The same cognition and determination of laws governing the world serves at the same time as the most correct means of mastering the above-mentioned forces, phenomena, and bodies and channeling them so that they will serve and benefit man" (8).

Unlike idealism and agnosticism, which denied the possibility of understanding nature, Dokuchayev was firmly convinced that each and every object or phenomenon could be understood and its properties could be completely revealed. To do this it is necessary to investigate comprehensively the object under study and study all factors of its formation and development. He plainly stated that ". . . to understand really a given organism or any body, in general, it is essential. . . to study thoroughly all, or as many as possible, of the conditions which have affected its formation and nature. . . " (7). Or, in other words, "To study more thoroughly these phenomena in their interaction and casual relationship. . . " (7).

Dokuchayev believed that it is quite possible "to approach the correct solution" to the problem of soil groups and their properties and geographical distribution in various countries. The first step in this direction should be "an analysi of present conditions." Pointing to the way of studying soils and their properties, he asserted that "the soil could be mastered and controlled. At the same time he realized however, that it would be difficult to obtain immediately the desired knowledge because of the extremely con plex nature of the continually and constantly changing conditions which affect the soil.

Dokuchayev's idea of the development of man's knowledge was original and convincing. Many of his positions indicate that he was already approaching the correct interpretation of cognition as an endless progress of man's thinking from ignorance to knowledge and from simple to more complex knowledge. Many times he expressed the idea that man cannot reach absolute knowledge at once but in a series of steps, and that it forms gradually from comparatively changeable truths. Dokuchayev wrote: "The knowledge we possess is not absolute and final, but human and changeable. Those truths which were once considered as ultimately established are being replaced by new ones. The volume of our knowledge is constantly expanding" (8).

Dokuchayev was approaching the correct understanding of the relation between the absolute and relative truths. Owing to his scientific solution of this problem he was able to overcome the limitations inherent to idealism and metaphysics. While idealism rejected the concept of objective truth and the role of relative truth in the process of cognition, and metaphysics failed to recognize the dialectical interrelation between relative and absolute truth, Dokuchayev emphasized: ". . . I am telling you a human and relative truth and not a "divine" and absolute truth. . . our science strives toward this absolute truth and its contents are constantly expanding and changing. The same is true of the knowledge of soils: all our knowledge has only a relative importance" (8).

On the basis of this Dokuchayev came very close to the correct understanding of the continual process of scientific development. He stated that ". . . contemporary soil science is far from perfect and that the present methods of soil research will be improved with time. . . I do not know of any science of which it could be said that it is not going to advance" (6). At the end of his classical work "Russian chernozem" he wrote that the results of his geological and geographic soil investigations are only the foundation of a new science — genetic soil science. But "Could one assume that these data bring to an end the study of Russian chernozem No, and No. !. " (5).

Unusual for that time and correct in its principle was Dokuchayev's view of the problem of the relations between various branches of natural science. Dokuchayev set out to show th e and the same subject of study has many dif- ent aspects and properties, which are in- tigated by different branches of natural ence, which must be related together by the ect under study and its general properties. many of his works he attempts to determine place of soil science in the system of natural ences. In doing so, he makes timid toward clarification of the relationship between losophy and natural sciences, the attempts find and show the connecting line between m, which lies in the most general properties objects and phenomenon and their laws. In pressing it he notes "... it may be and en really is that we are dealing with the ne body, the same rock or mineral, and the ne ore! but the approach... of specialists to s object, the purpose of its investigation, the thods of study and solution relative to this blem are all very different" (8).

According to Dokuchayev, natural science as hole should encompass the combined relation- p of all aspects, properties, and qualities give a comprehensive idea of an object. In er words it should "... bring them to- her and even relate them, thus recreating, to say, the unity of nature and its cognition" This demand for a synthetic approach to an ect and its study as a whole was one of the racteristic features of Dokuchayev's scien- c method. He thought that "... it is quite sential to study the nature of Petersburg and vicinity as a whole and in a comprehensive nner (from the natural science point of view physiographically), if possible, rather than nmarily its individual parts and elements"

He paid especial attention to the comprehen- e examination and thorough analysis of all racteristics of a phenomenon under study. the same time he stressed that the deter- nation of the essential, basic properties of object or phenomenon is the main element of nition. He pointed out that we cannot con- er an object to be understood fully as long as "... do not know all the essential" (4). He isted on the principle of the necessarily dying... "... all those main elements" which are characteristic for a given soil. ny times he emphasized that one of the main uirements of cognition should be the in- ht into "the essence of the phenomenon," a rough study of its most important aspects of ationship, basic properties, and causes for stence and development.

Dokuchayev's position that cognition should divided into current and perspective cogni- which are inseparable from each other has ery profound meaning. He believed that both es of cognition should be closely related to and be determined by practical economic uirements. He advised scientists that in dying Petersburg they should pay attention only to such bodies (for instance, infectious er organisms) or phenomenon (for instance, ods) which at the time appear most important nan, but also to those which may seem at moment to be of little or no use.

The necessity for such studies is determined he following considerations: ..."1) nobody nothing could vouch that a preferential study of these bodies and these phenomena would be most useful and good for man; 2) some new scientific fact or a new discovery that today seem to be of only a purely theoretical importance, foreign to life, tomorrow may assume a great vital and practical importance" (8).

Such an approach to cognition indicates that Dokuchayev was already aware of the necessity for the human mind to penetrate natural phenomena and to discover their inner relations and connections. He understood that only a constantly expanding and deep knowledge of the nature surrounding man can serve as a solid basis for his practical activities. He showed on the bases of examples taken from life that impassable swamps and marshes, which give man a lot of trouble for a long time, could change into fine meadows, orchards, and vegetable gardens and be of use to man. By the same token, storms and floods that instilled terror in man could become powerful motive forces. The only way to realize this is first to study these phenomena thoroughly and then master them. Dokuchayev pointed out that "Everything about nature is beautiful. We only fear such enemies of our economy as winds, storms, droughts, and dry winds because we do not know how to master them" (8).

One of the outstanding features of Dokuchayev's activity was his struggle against inertness in science. He pointed out that natural sciences must develop continuously. Noting that the honor of stating and solving the main problem of the natural relationship between phenomena and processes which occur in soils and affect their geographical distribution belongs to Russian genetic soil science, Dokuchayev believed that this does not exhaust the knowledge of the forces of nature and soils. In his opinion soil science "... is going through a creative phase. Only recently conceived ideas are rapidly developing, throwing light on the subject from the most various points of view. Hypotheses give place to precise theories, methods are being constantly improved, and the vast amount of facts and observations is being shaped into a regular system" (8). In our opinion, Dokuchayev used the right approach to the study of internal forces motivating science. He believed that the conflict of opinions, which is one of the sources of development, does not let science stand still and because of this it is constantly moving forward. He quite frankly stated that the knowledge obtained without "criticism" should be used "... with, at least, great caution" (4).

Dokuchayev was critical of all methods and techniques of soil research used before his time. He worked out and extensively used his own principles and methods of soil investigation, such as: the comparative method, the method of grouping and complex study of bodies and phenomena, and also the specific geographical-morphological soil method. Owing to this, not only soil science but natural sciences as a whole were enriched with new principles and methods of investigation.

Dokuchayev's objective in studying a phenomenon or a natural body was to clarify the nature and course of natural processes taking place both during the formation of a body and during its further development. And he never dropped an object he studied before achieving his goal. Precisely in this way was he able to penetrate into the essence of processes and determine their causes and laws of their existence.

He strictly adhered to his own principle of observing nature as much and as often as possible. However, to him this was not an end in itself. He realized and constantly stressed only such knowledge of the laws of nature which could help man to master natural forces and bodies and use them for his practical needs. In the introduction to his great work, "Russian chernozem" Dokuchayev pointed out that ".... I tried to study chernozem whenever possible from the scientific natural-history viewpoint... that only on this basis, and after a comprehensive scientific determination of this basis, can various practical measures be established to improve agriculture in Russian chernozem belt" (5).

Another outstanding feature of Dokuchayev's creative activity was the fact that he was able not only to find scientific truths, but also to defend them. With all his power he fought against the use of science for personal profit. He exposed the bourgeois, exploiting attitude toward natural sciences on the part of the representatives of the ruling class who used science for their selfish interests. Speaking of the work which scientists perform under difficult conditions in seeking the truth and the later misappropriation of scientific achievements, Dokuchayev wrote: "... today a poor scientist must often spend his last pennies and strength on research, and tomorrow other people may use it to make literally thousands and millions" (8).

In his diversified activities Dokuchayev was neither a stark empiricist nor an armchair scientist with various unfounded theories and hypotheses. One of the important features of his creativeness was the fact that he almost succeeded in gaining a scientific understanding of the role of experience and the practical activity of man in the process of cognition and transformation of nature. Unlike idealism, which denies the role of practice in cognition, Dokuchayev saw it as the basis of cognition and transformation. He tried to overcome the contemplative approach to nature and to show the active influence of man on natural phenomena and processes. He often emphasized that true knowledge is only that which includes "experience" gained from the practical activity of man. This enabled him to correctly approach the statement and solution of the problem of the essence of nature and its place in society. Dokuchayev saw the strength and practical importance of science in the comprehensive and complete cognition of natural bodies and phenomena and in the discovery of its objective laws. He believed that on the basis of science man can improve his methods of production. He pointed out that science makes it possible to use certain natural bodies and phenomena and to control natural processes. He realized that science in the hands of the people represents a great transforming force and wrote that "The foundations of soil science serve as a cornerstone for the entire structure of agriculture. The knowledge of these foundations is essential for each farmer" (8).

It was clear to Dokuchayev that a rational agriculture should be based on a preliminary thorough study of the soil, climate, and other natural factors. These factors "... should be studied in their genetic interrelation and, first of all, in their relation to man..." (8).

In applying this principle, Dokuchayev tried to provide scientific answers to problems pertaining to soil. He said: "Only after a comprehensive study of a soil can one positively sa what may be sown on it (8) and thus introduce t scientifically obtained truths into life, practice, agriculture" and "invest abstract truths with life" (7). He noted that only "... thorough geological and soil investigations could be of help to the local population" and could tell how "... crop yields could be increased" (8).

Dokuchayev's investigations were closely related to practical needs. He sought to work out and suggest measures for the rational use of agriculture suitable for specific local natural conditions. As one of such measures he insiste on the necessity for the arrangement of agricultural production by regions and the establishment of differential farming techniques. He believed that the division of Russia into regions i the most important problem from the scientific as well as practical points of view, because it is closely related to "The type of agriculture methods of soil tillage, agricultural crops, typ of fertilizers, and, in general, the entire method and structure of agriculture" (8).

After analyzing the importance of the cognition of soils and other natural conditions for agriculture, Dokuchayev came to the conclusio that "Without this knowledge and without a thorough acquaintance with the forces of nature its resources and its free blessings, the farme would always be helpless like an armless worker. He would always be a slave of accidental events, suffer from poor harvests, which have recently occurred almost annually, be constantly subject to the risk of unnecessarily wasting his labor, and lose his earning and his means for existence. Not knowing the physical composition of soil, the properties of the wate in it, or air surrounding it, the plant and anima kingdom, we would always be helpless in our struggle against such elements as droughts, haze, storms, hail, etc." (8).

Dokuchayev tried to discover and show man' role not only in cognition but also in the transformation of nature. In his book, "Our steppes now and before" (1892), and in other works, he pointed out that on the basis of the knowledge o natural laws man can prevent the terrible calamities caused by crop failures; that man ca effectively fight droughts and strengthen his co trol over natural forces; and that "... human interference and the art of the agronomist" can create favorable conditions "... for the life of crops" (6).

Dokuchayev had no doubt that from the time man first started to cultivate the land and produce grain he has been interfering more and m with natural soil processes and modifying them This interference and the nature of its effect o the process of soil formation depend on "... the objectives of the farmer and the means at h disposal" (6) and may manifest themselves in t ys, depending on the social-economic condi- ns in a given country. In one case man can rich soil fertility and in the other he can ex- oit it.

Dokuchayev realized that by using mechanical thods of cultivation, fertilizers, and other asures, man can give the desired direction the process of soil formation and create soil operties and qualities needed by crops and ain constantly high yields. At the same ne, while analyzing the nature of the landlord- pitalistic economy of Russia at the end of the h century, he noted that this economy was sed on the principle of "...stock-market mble" (7) and a predatory attitude toward d. He wrote: "...I have no doubt that the l, just like anything else in the world, is anging and if something is constantly taken m it and nothing given back, the soil will urally deteriorate" (7). This cannot be oided "...as long as the activity of man is ected only toward the deterioration of natural nditions of our country, and not toward their provement...as a result of the most sense- s use and exploitation of the natural re- rces of Russia" (7).

Dokuchayev attributed an important cognitive e to the producers of material goods — the ssian farmers. For centuries they have been cumulating facts from their practical ex- rience which served as a basis for theoretical neralization in science. Dokuchayev was one the first scientists who established that the al names for soils adopted by science, such "chernozem," "podzol," "solonchak," lonetz," were "throwing light on various soil ups." He noted that "The people are very d at noticing certain regularities and always w how to take better advantage of the forces nature" (8). He believed it necessary that entists be in closer contact with the people study its experience, and urged them to do In the work "Advantages of studying the al nomenclature of Russian soils," he ex- ined the importance of the people's experience the development of science, in general, and soil science, in particular.

In noting the positive role played by the rking people in determining the quality and perties of soil, Dokuchayev wrote: "...the mers often judge of the fertility of the soil.. by its richness in humic substances. I may , on the basis of my many years of travel in sia, that our farmers, even the simple sants, even more often evaluate soil by its or. "This is a darker soil, and a better one; is white ash, not worth tilling" (3). He ed that the people have noted long ago that in the forest differs depending on the type orest. The peasant knows perfectly well the erence between the soil in a basswood forest, oak forest, and a pine and spruce forest. uchayev emphasized that "It turns out that he solution of the origin of chernozem, as many other things, the people's knowledge is re advanced than science" (5).

n his role as a naturalist and a thinker, uchayev created, in his own words, "...a ching about the complex and diversified inter- tions and interactions between the so-called ng and dead nature, and the eternal laws governing their changes. Such interrelations and interactions as between a) surface rocks; b) the plasticity of the earth; c) soils; d) surface and ground water; e) the climate of a country; f) plant; and g) animal organisms (including, primarily, the lower forms); and man — the crown of creation" (7). This is a perfectly precise and clear definition of the essence of the theoretical and philosophical principles of soil science, which were an important contribution to Russian and international natural sciences.

Dokuchayev's ideas and principles played a decisive role in the development of soil science in the world. This true teaching of soil was propagandized by soil samples and English and French translations of Dokuchayev's and his students' works which were exhibited at the World Fair in Paris (1889) and the Columbia Exhibition in Chicago (1893). The ideas of genetic soil science has a great influence on scientists in Western Europe as can be seen from an article by Professor E. Ramman of the University of Munich which was published in the journal "Pochvovedeniye" in 1901. Dokuchayev's name and ideas were widely found in the literature on soil science in the United States at the end of the 19th century and, especially, at the beginning of the 20th century. One of the progressive American scientists and a great naturalist-theorist, K. F. Marbut, gave the following evaluation of Dokuchayev's school in the development of world soil science: "Dokuchayev and his associates occupy the same position in soil science that Charles Lyell and his associates occupy in geology." International congresses of soil scientists at which "the great Dokuchayev" was mentioned represented a triumph of Russian soil science.

The materialistic traditions in soil science initiated by Dokuchayev are deservedly highly valued because he arrived at them under extremely complex and difficult conditions prevailing in Russia's scientific life of that period, when idealism and metaphysics were binding scientific thought and slowed down the development of progressive ideas in natural science. However, this scientist was able to penetrate and understand correctly many natural phenomena, their interrelation and interaction. Dokuchayev demonstrated an unusual determination in his fight against reaction in politics and idealism in science. He managed to retain his materialistic positions and to propagandize forcefully the ideas of progressive natural science.

Dokuchayev's works serve as one of the bright examples of that spontaneous yet profound penetration into the dialectics of nature and its reflection in the human minds which are characteristic for all great classical natural scientists. The great value and importance of Dokuchayev's natural science and philosophical work are also apparent at the present time when Soviet scientists, following the materialistic trend started by Dokuchayev in genetic soil science were able to develop it further, on the basis of data obtained by modern science and the practices of socialistic agriculture, and penetrate deeper and more fully into natural phenomena, understand them and on this basis further improve socialistic agriculture.

At the same time Dokuchayev made certain sociological errors as did many other outstanding naturalists of his day. He overestimated the importance of the geographical environment in the development of human society, and mechanically applied to sociological problems the law of nature, which, in his opinion, could play a fatal role. He believed that nationality, its nature and the mental and moral characteristics of man are determined by natural factors. He also overestimated the importance of science and education in fighting the social evils of the bourgeois-serfdom regime in Russia.

Dokuchayev's scientific legacy was further developed and expanded by Russian and, especially, by Soviet scientists. Thus, Academician V. P. Vil'yams used Dokuchayev's materialistic premises to expand and deepen the methodological foundations of genetic soil science. He was much more successful in revealing the philosophical essence of the process of soil formation and evolution, and he also developed and substantiated the biological aspect of soil-formation.

Vil'yams founded the teaching of soil fertility and established the theory of a unified process of soil-formation. He more fully substantiated the concept that soil is not only a natural body, qualitatively different from unfertile rock, but also the most important means of agricultural production. Vil'yams gave a more precise definition of the place and role of soil in nature and of its importance for human society.

Dokuchayev's soil science has now acquired a great meaning. The experience of the socialist agriculture has confirmed the correctness of the basic ideas and principles, as well as of the concrete measures suggested by Dokuchayev. The system of measures developed by him, such as shelterbelts, the building of dams, irrigation of arid lands, the drainage of swamps, the introduction of grass rotation, conservation of the soil structure and soil fertilization, have not lost their importance to this day. They constitute an integral part of the complex scientific agronomic system which bears the names of V. V. Dokuchayev, P. A. Kostychev and V. P. Vil'yams, and which has been further developed and enriched by modern theory and socialist practical experience.

Dokuchayev's creative activity represents an example of a comprehensive approach to the study of natural bodies and phenomena and of their materialistic explanation. It combines broad scientific investigations, theoretical conclusions, and philosophical generalizations. In Dokuchayev's works one finds a profound treatment of the philosophical problems of soil science, which has a great theoretical importance in our time for the dialectic-materialistic interpretation of modern soil science.

Received February 5, 1960

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UTLINE OF PRINCIPLES FOR THE RECLAMATION F SOILS IN THE AMUR OBLAST'

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In the Amur Territory agriculture is con-trated in areas characterized by rolling in, plain, and plain-lowland relief. The lowing have the greatest agricultural develop-nt: the Zeya-Burieya and the Amur-Zeya cumulative plains in the Amur Oblast', the ds of the Jewish Autonomous Region in abarovsk Territory, and the Khonkay lowland the Maritime Province.

Because of unfavorable physiographic con-ions, a considerable part of the plains is le used or not used at all for agriculture. the best and most fertile areas excess mois-e interferes with agriculture.

Excessively wet arable lands in the valley tion of the Amur region are due to the pres-e of numerous enclosed micro- and meso-ressions in flat-topped watersheds and their tle slopes; they cause the mass waterlogging agricultural crops when they become over-ed with water during monsoon rains, and erfere with surface runoff on the positive ments of the relief. Water logging of the a is promoted by a dense network of hum-cked hills (ravines) with inadequate drain-outlets and a poorly-developed drainage work. As a result of erosion, most of the al rivers no longer serve as a drainage tem and are cut off from the main rivers. ound water is found at a considerable depth -40 m) except in flood plains and the first er terraces.

In arable areas soils and parent materials are fine textured,have negative hydrophysical properties and low coefficients of water yield (0.2-0.1) and permeability (0.37-0.03 m/day). It should be noted that thick layers of medium-grained tertiary sand which are found at varying depths (2-6 m) have a good water permeability, reaching up to 21 mm/minute.

In the Amur Oblast', more than 80% of annual precipitation occurs during the second half of summer when the moisture requirement of plants is small and its loss on transpiration and physical evaporation is low. This is confirmed by the data on the water use coefficient in different areas of the Amur Oblast' (Table 1).

Table 1

Coefficient of water use

Observation points	Months				
	V	VI	VII	VIII	IX
Maritime territory experimental station	1,4	1,6	1,3	—	1,4
Gosh	0,7	1,1	2,8	2,4	—
Bomnak	—	—	1,4	2,1	1,4

Note: Comma represents decimal point.

Table 2

Precipitation during the growing periods from 1953 to 1955, in % of the long-period mean annual total precipitation

Years	Months					
	V	VI	VII	VIII	IX	V—IX
Long-period mean	8,1	20,6	23,5	22,2	15,0	89,4
1953	36,0	16,0	48,4	20,4	9,0	129,8
1954	3,2	23,1	1,3	6,3	19,6	53,5
1955	8,7	33,9	25,7	28,5	31,7	129,0

Note: Comma represents decimal point.

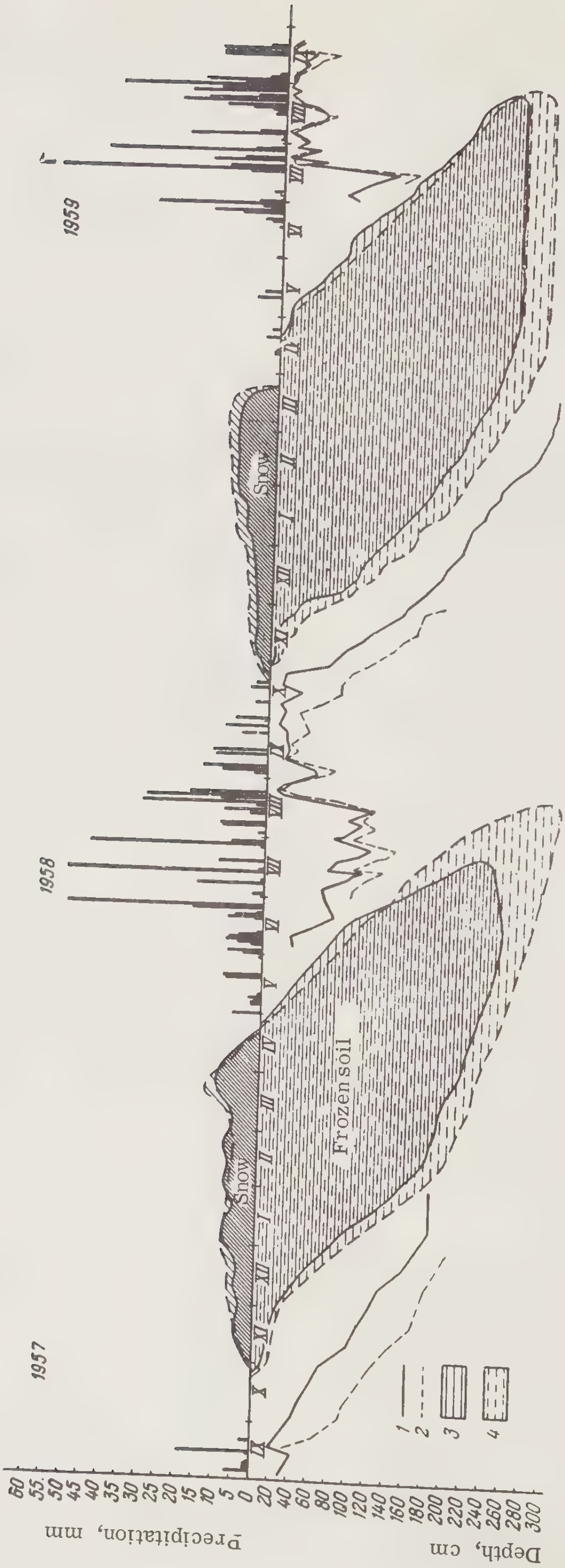

Fig. 1. - Ground-water (temporary water table) level dynamics in relation to precipitation and frozen soil. Belovezh station. 1 - water table in the forest; 2 - water table in the field; 3 - frozen soil in forest; 4 - frozen soil in field.

Table 3

Spring wheat yield in relation to total precipitation during the growing period (data of the Amur Oblast' agricultural experiment station)

Larger than average wheat yield			Lower than average wheat yield		
Years	In % of the mean yield in the Oblast'	Total amount of precipitation during the growing period, mm	Years	In % of the mean yield in the Oblast'	Total amount of precipitation during the growing period, mm
1913	150	370	1917	95	580
1916	113	370	1920	68	625
1918	130	280	1921	54	140
1919	108	290	1928	94	600
1922	142	390	1929	73	605
1927	160	280	—	—	—

Studies of soil moisture content in various
ts of the Amur Oblast' showed that when the
g-period mean annual amount of precipita-
n (465 mm) is exceeded by 40% (1953 and
5) it causes excess soil moisture and the
nation of soil water (temporary water
e); when precipitation is 40% less than
long-period mean, droughts occur (1954,
le 2). In both cases crop yield is low.

Figure 1 shows under what conditions
water (temporary water table) forms and
dynamics, in relation to the amount of
cipitation and frozen soil.

Long-periods of meteorological observa-
s indicate that the highest crop yields are
ined during the years with moderate
unts of precipitation, such as 280-390 mm
ng the growing period, or 465 mm a year
le 3). Our previous investigations (16)
also shown that the previously mentioned
al amount of precipitation is normal for
Amur Oblast'.

oils formed under conditions in the Amur
st' differ in their potential fertility. The
int of humus in their upper 100 cm varies
ollows: 313-340 metric tons/ha for thick
dow chernozem-like clays; 244-264 metric
/ha for moderately-thick meadow cher-
m-like clays; 140-150 metric tons/ha for
meadow chernozem-like clay loams; 164-
netric tons/ha for meadow-bog clays;
184 metric tons/ha for bog peaty-humic
; 143 metric tons/ha for flood-plain mea-
clay loams; 113 metric tons/ha for mea-
brown clays; and 68 metric tons/ha for
n forest podzolized clay loams.

e foregoing shows that a considerable
of the soils found in the Amur Oblast'
a high potential fertility. However, brown
t soils and their varieties formed under
erous-broadleaf forests on coarse-tex-
soil would require much effort for their
ation and erosion control. It would be,
fore, more economical to use such soils
dissected relief for forestry purposes.

It should be noted that 40%-70% of humus, and correspondingly, nutrients, is concentrated in the upper layers that are aerated to a greater or lesser degree. There is only an insignificant amount of available phosphorus in the soil because this element is bound here by lower forms of iron and aluminum oxides. In general, because of intense reducing processes, the availability of nutrients in the soils of the Amur Oblast' is low. These soils readily respond to phosphorous and nitrogen, and application of mineral and organic fertilizers cause a substantial increase in crop yields.

Thus, because the drainage network has lost its original importance as a result of erosion and the gently-rolling plain relief abounds in enclosed meso- and micro-depressions, they do not provide for proper drainage and surface runoff during the monsoon rain season. The unchanneled runoff water floods large land areas, and rivers often overflow because of their underdeveloped beds, and inundate neighboring areas.

Because of the finer-textured parent material, its low water-yield coefficient and prolonged seasonal soil freezing, the water table is high. This resulted in the formation of complex soils with a gleyed profile, with a structureless horizon below the plowed layer, negative hydrophysical properties, and considerable amounts of nutrients.

Normal development of agriculture in the Amur Oblast' is only possible if the following complex reclamation measures are taken:

1) improvement of the hydrophysical properties of soil; and 2) regulation of surface and subsurface runoff.

Reclamation measures directed toward the control of excess moisture and drought in the Amur region are described in Table 4.

Received January 18, 1960

Table 4

Scheme for the reclamation of soils in the Amur region

Source of water logging	Relief	Proposed agricultural use	Soil	Characteristics of soils and system of measures for their improvement	
				Water-permeable	Slightly-water-permeable
				Water-intake >30 mm/hour, CGF^a >0.5 m/day, Resistance - $\rho \leq 0.3$	Water-permeability <30 mm/hour; CGF <0.5 m/day, Resistance - $\rho > 0.3$
I. Atmospheric precipitation	Watersheds and their gentle slopes	Crop-rotation of all kinds	Meadow, chernozem-like thick, moderately thick, thin; meadow-sod-podzolized moderately thick and meadow-sod weakly podzolized thin, fine clay loam and clay combined with up to 10% of bog soils		1. Regulation of surface runoff of monsoon rain totaling more than 600 mm a year by means of ponds and reservoirs (about 20% of the total annual amount is regulated). 2. Moling and mole drainage at an incline of more than 0.003, mole drainage is made when the moisture content is 27%-28% which corresponds to the time of fall soil tillage. 3. Furrowing of fields. 4. Periodical elimination of plow pan and accumulation of moisture in the lower part of soil profile by loosing the horizon underlying the plowed layer to a depth of 40-45 cm (on positive relief elements). 5. Plowing along slopes when the incline is 0.003-0.005. 6. Introducing crops with large transpiration coefficients (corn, sorghum, perennial grasses) in crop rotation. 7. Improvement of hydrophysical soil properties by sowing perennial grasses, green manuring, and by applying organic and mineral fertilizers.
II. Atmospheric precipitation	Watersheds, slopes, small hills	Crop-rotation of all kinds	Meadow-sod-podzolized clay loam. Brown forest clay loam and their varieties	1. Improvement of hydrophysical properties by introducing perennial grasses into crop-rotation, by green manuring, and by applying organic and mineral fertilizers. 2. Plowing across slopes. 3. Afforestation of steep slopes and other	

Source of water logging	Relief	Proposed agricultural use	Soil	Characteristics of soils and system of measures for their improvement	
				Water-permeable Water-intake >30 mm/hour, CGF[a] >0.5 m/day, Resistance - ≤ 0.3	Slightly-water-permeable Water-permeability <30 mm/hour; CGF <0.5 m/day, Resistance - >0.3
				4. Sandy and little developed crushed stone soils are used in forestry.	
III. Atmospheric precipitation and water from uncontrolled surface run-off	Flat-top watersheds and their gentle slopes with enclosed meso- and micro-depressions	Crop-rotation of all kinds. Hay fields and pastures	Meadow chernozem-like combined with peaty-gleyed and humic-gleyed soils; sod-peaty-podzolic-gleyed; meadow-bog humic and peaty clay (dwarf arctic birch)		1. Drainage of meso- and micro-depressions by means of open ditches; control of surface runoff by means of ponds and reservoirs; partial channeling of excess water into rivers. 2. Vertical drainage in dry sand. 3. Future moling and mole drainage. 4. In the future same measures as. for Section I. 5. Sowing rice in the southern districts by using various fields and the principle of migrating water reservoirs; using for this purpose wide river flood plains after clearing and straightening them. 6. In hay-harvest fields and pastures, Volkov's method of cuts.
IV. Water from external waterways	Hollows and ravines	Hay fields and pastures	Meadow-bog, peaty- and peat-gleyed and humic-gleyed	Water-collecting ditches, grubbing of hillocks, sowing of grasses	Upland and water-collecting ditches, grubbing of hillocks, sowing of grasses.
V. Ground water, and ground water under pressure	Depressions flooded by spring water	Hay fields and pastures	Meadow-bog, peaty- and peat-gleyed and humic-gleyed clay	Straightening of spring channels, peripheral waterways open drainages, grubbing of hillocks, sowing of grasses.	Straightening spring channels, peripheral water-collecting channels, open drainages in combination with temporary drainages, grubbing of hillocks, sowing of grasses.
VI. River flood water	Flood plains of large and small rivers	Crop rotation of all kinds. Hay fields and pastures	Meadow flood-plain clay loams; meadow-bog; peaty- and peat-gleyed and humic-gleyed clay and clay loam	Regulation of river discharge, straightening and widening of small river channels. Lowering the water table. Collecting network to channel excess water. Grubbing of hillocks.	Regulation of river discharge. Protective dams. Straightening and widening of small river channels. Collecting network to channel excess water.

Remarks: References 1-26 were used in compiling this scheme. [a]Coefficient of permeability.

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OME DATA ON THE THERMAL REGIME OF USSR SOILS

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Study of the thermal regime of the soil is asic importance. The underlying sur- e is one of the most important factors in formation of weather and climate, since heat balance of the atmospheric layers the ground depends on the properties of surface. In its turn the process of soil nation is, as is known, associated with nate.[1]

Vide use is made in agriculture and in engineering of data on the thermal regime e soil at various depths. Information on depths to which the soil is frozen is of great ortance to building structures in the perma- t zone.

his article is concerned primarily with solution of the first of these problems, all numerical features cited will only re- o the upper layers of the soil.

ystematic observations of soil tempera- were started in Russia at the close of the century. We now have soil temperature for several hundred areas: in view of the and varied relief of our country however, ave to admit that there are still too few suring points in the North, in uninhabited of Asia, and in mountain districts.

il temperature is normally measured natural cover (grass in summer and in winter). Parallel observations on ed surfaces are also made at a number nts. The thermometers are normally set various depths in the soil layer down to and observations down to a depth of 6-8 available at some points.

is quite difficult, for the following rea- to analyze and classify the recorded s.

e thermal regime of the soil is funda- lly dependent on its composition and ure, moisture, and the nearness of ground waters. In winter the thickness and density of the snow greatly influences soil temperature, since owing to its low thermal conductivity the upper soil layers are insulated against temperature conditions in the adjacent atmospheric layers. Specific difficulties arise when measuring the temperature of the soil surface, since the thermometer readings can vary greatly in relation to the position of the thermometer bulb on this surface. In winter the active surface is not the surface of the soil but the surface of the snow. Observations at depths of 5, 10 cm and 15 cm, essential to agriculture, are only made when there is no snow.

We cite data for depths of 20-25 cm (Tables 1 and 2) to give some idea of the order of magnitude of the differences in soil temperature as a result of the reasons mentioned previously.

These are near-surface depths, for when we have several sets of measurement data covering the whole year and not merely the warm period.

The differences in soil temperature at these stations are largely due to the fact that on the Moscow plot the soil was a podzolized clay loam, whilst on the Orshinskaya estate it was mossy bog covered by half-grown forest.

Soil temperature is considerably lower in the cold months and higher in the summer over the bare surface than over a surface with natural cover. The magnitude of the temperature differences depends on the thickness and density of the snow cover and on the composition and structure of the soil. Temperature differences are less in the South. When the natural cover is sparse burnt grass that does not form continuous cover the temperature at the surface, and in the upper layers of the soil in summer, can be higher than at a bare surface. The reason for this is a decline in the heat exchange between the soil and the atmosphere without any basic weakening in incoming radiation and the almost total absence of heat loss from evaporation.

When processing soil temperature records one should remember that the sets of readings are of unequal length and that many of them are short, since it is only of late years that there has been a great development in the

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e can, for example, point to the good agreement opean Russia between the Southern boundary ordinary chernozem and the July air tempera- he 22^{0}C isotherm) in the area from Orenburg western frontier of USSR.

Table 1

Differences of mean monthly soil temperatures (°C) at a depth of 25 cm in Moscow (Timiryazev Agricultural Academy), and on the Orshinskaya Estate, 1911-1920

Months											
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
—1,6	—1,5	—1,0	0,7	3,5	5,1	5,3	4,0	2,1	—0,5	—1,7	—1,7

Table 2

Differences of mean monthly soil temperatures (°C) on bare ground and beneath natural cover at a depth of 20 cm

Area	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Leningrad (Forestry Institute), 1893-1907	— 6,1	— 6,3	—3,1	1,4	2,3	3,9	3,5	1,4	—0,2	—0,8	—1,3	—4,3
Sverdlovsk, 1901-1937	—11,3	—10,4	—5,1	1,5	2,7	3,8	3,7	2,3	0,4	—1,4	—4,1	—9,3

Note: Comma represents decimal point.

Table 3

Mean deviations of air (a) and soil (b) temperature (°C) at a depth of 20-25 cm

Area		Months											
		I ±	II ±	III ±	IV ±	V ±	VI ±	VII ±	VIII ±	IX ±	X ±	XI ±	XII ±
Moscow	*a*	3,2	2,8	2,2	1,9	1,9	1,5	1,3	1,6	1,3	1,8	2,0	2,5
	б	0,8	0,7	0,4	1,2	1,5	1,4	1,2	1,1	0,9	1,2	1,0	0,8
Sverdlovsk	*a*	2,6	2,4	1,9	2,0	1,8	1,5	1,3	1,1	1,2	2,0	2,4	2,8
	б	1,0	1,1	0,7	0,9	1,4	1,3	1,2	0,8	0,6	1,0	0,7	0,9
Kirovodgrad	*a*	2,9	2,5	1,9	1,5	1,4	1,2	1,2	1,2	1,4	1,7	2,0	2,4
	б	1,6	1,1	1,0	1,4	1,7	1,6	1,4	1,7	1,5	1,3	1,4	1,2

Note: Comma represents decimal point.

network of stations. This may mean that data from different areas cannot be compared with each other, especially in our epoch, in which there is a clearly defined change of climate.

Table 3 gives some idea of the variability of soil temperature from year to year and of its relationship to variation in air temperature.

When the ground is covered by snow the soil temperature fluctuates less from year to year than does air temperature: this means that the mean temperature deviations of the air and the soil are practically equalized: in the South soil temperature is more variable than air temperature in the summer from year to year. In Moscow, snow settles on November 3, and departs on April 7. In Sverdlovsk the corresponding dates are October 15, and April 22, and in Kirovograd, November 25, and March 20. There is therefore a marked difference in the variability of air and soil temperature in Moscow from November through March, in Sverdlovsk from October through April, and in Kirovograd from December through March.

When determining the duration of a series of soil temperature readings from which the temperature could be calculated with the same accuracy as air temperature, we concluded that the duration is the same for both elements in summer but that soil temperature does not require such long periods in winter.

It does not follow from this, however, that short series of soil temperature observations at a depth of 25 cm will yield high accuracy. In Moscow the average soil temperature in winter, calculated for one 20 year period can differ by 0.5-1.0°C from the temperatures for a second 20 year period, and the same order

Table 4

Soil temperature differences (°C) at depths of 5 cm and 20 cm

Area	Months					
	V	VI	VII	VIII	IX	X
Khibiny	—	2,6	2,3	0,9	—0,6	—
Vologda	1,6	2,4	2,7	1,6	—0,7	—1,1
Voronezh	1,8	2,1	1,6	1,0	—0,3	—1,2

Note: Comma represents decimal point.

difference is observed in May.

Special methods devised for climatological
ocessing of soil temperature observations
ere used by a large group of climatologists
the Chief Geophysical Observatory and in
e local organizations of the hydrometeorologi-
l service to process the large amount of ma-
rial accumulated over a number of years on
ean monthly soil temperature, the number
days with frost in the soil, and the depths
which a temperature of 0°C penetrates.
S. Perunovaya has compiled maps of soil
mperature distribution at various depths
om 0.2 to 3.2 m (isotherms) for the plains
the USSR.

We shall not here examine the methods used
processing the soil temperature materials,
ice they have been given in detail elsewhere,
luding a textbook of climatology.[2]

The lack of sufficient direct data on soil
nperature for considerable parts of the
intry forces us to seek its relations with
er metrological elements, the most impor-
t of which is air temperature. Since air
nperature distribution throughout the terri-
y has been well studied, one could use it
assess soil temperature if sufficiently re-
ble relations between air and soil tempera-
e could be established. It is, however,
y when there is no settled snow that the
relation coefficients between air and soil
nperature (at 20-25 cm) are significant.
us, at Moscow the correlation coefficients
ctuate between 0.75 and 0.88 from April through November, and at Sverdlovsk from April through October between 0.68 and 0.84, while for the remainder of the year they are slight.

For the greater part of the year throughout almost all of the Soviet Union the soil temperature at depths of 20-25 cm under natural cover is higher than the air temperature at a height 2 m from the surface. It is only from April through July (from May through August in the Far North) that soil temperature is lower than air temperature. The greatest differences (14-19°C) between soil and air temperature are recorded in Asiatic Russia in January and December. On the Northern and Eastern seaboards these differences are somewhat less.

In the South of the Soviet Union soil temperature is higher than air temperature throughout the year. Temperature differences are greater in summer and fall than in winter owing to the non persistent snow cover (or total absence of snow cover) and the great heating of the soil during the summer. Soil temperature is also higher than air temperature throughout the year in the mountain districts of the Caucasus and Central Asia at an altitude of approximately 3500 m, but since the winter is more severe the temperature differences in the cold months are greater than in the summer.

The data of Table 4 gives some idea of the summer temperature regime in those layers of the soil that are closest to the surface.

Despite the great differences in the geographical situation of these areas and in the composition of the soil (podzolized soils and chernozem), the temperature differences are quite stable and are thus typical of an extensive territory.

Received December 30, 1959

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SEPARATION OF HUMIC ACIDS BY THE CONTINUOUS PAPER-ELECTROPHORESIS METHOD

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According to current opinion, a humic acid is not a chemically distinct substance but a system of substances which, while possessing common structural features, are not completely identical with one another. This view has been put forward by Tyurin (4), and by Kononova and co-workers (1, 2, 3). Among foreign scientists, Welte (7, 10), Niemann and Ziechmann (8, 9), and Scheffer (11) hold similar views. The British authors Davies et al. (6) believe that humic acid forms a polyanion.

In this connection attempts have been made both in the Soviet Union and abroad to separate humic acids into a series of fractions. Kononova et al. (3), using starch column chromatography, succeeded in separating the humic acids of a chernozem and a sod-podzolic soil into three zones. Scheffer (11), and Welte (7) separated humic acid by electrophoresis on strips of paper and obtained two fractions, corresponding in color to grey and brown humic acids. These authors believe that all humic acids are a mixture of these two fractions, with one or the other predominating (10).

To obtain the fraction characteristics of the humic acids, Welte used absorption-spectroscopy analysis (8). Two wave lengths, 472 mμ and 664 mμ, were selected for series of determination of the humic acid type. The extinction values E_4 and E_6 obtained with these wave lengths were used to determine the "coloration factor" $Q_{4/6} = E_4/E_6$. The characteristic $Q_{4/6}$ was between 5.0 and 5.5 in the case of the brown, and between 2.2 and 2.8 in the case of the gray humic acids. As Welte established, here the coloration factor of the gray humic acids depends on the nitrogen content in the molecule and is in inverse ratio to that quantity.

Since electrophoretic separation of humic acids on strips of paper cannot yield a sufficient quantity of the separate fractions, Scheffer et al. (11) recently went over to the continuous (precipitative) electrophoresis method. With this they succeeded in separating humic acid into 10-15 fractions, which they believe to represent a gradual transition from gray to brown humic acids.

Continuous electrophoresis has also been used by us in a work on the separation of humic acids. The principle of this method consists in the creation of an electrical field at right angles to a fluid flowing through a porous medium and containing the mixture to be separated in the middle of the jet. The misture under analysis and the buffer solution are moved at a constant speed through a system of paper sheet capillaries and the electric potential is built up perpendicularly to the direction of flow. The result is that the charged particles in the solution will move at a known angle to the direction of flow of the fluid. If the mixture to be fractionated is introduced into a narrow sector of the system, its components will form separate bands with different angles of inclination. Provided the rate of flow and the voltage are constant, the angle formed by the various belts will remain constant throughout. If there is no adsorption or evaporation, and if the electric field is uniform and constant, the separation effect will be a direct function of the length of time during which the mixture to be separated is in the electric field, and also a direct function of the size of the field itself.

As a method of separating substances, electrophoresis has a number of substantial advantages over other physical-chemical methods. This method makes it possible to separate a mixture of chemically similar substances, whereas with the conventional chemical methods a mixture of substances can be separated only into groups which appreciably differ in properties. The electrophoretic method is particularly valuable for separating substances for which water is the only solvent. In such cases even the now classical distribution chromatography method takes second place, for it requires the presence of a system of two or more solvents. Moreover, electrophoresis is one of the few methods of separation suitable for extremely unstable colloids. The same may therefore be said of th electrophoretic method as Zechmeister said about the color chromatography method — that it is a landmark in the history of chemistry because it allows a mixture to be separated into its components before analysis.

In our own work we used an apparatus for continuous electrophoresis designed by Ye. A. Fedorov. The general view of this apparatus is shown in Figure 1. In design it is similar

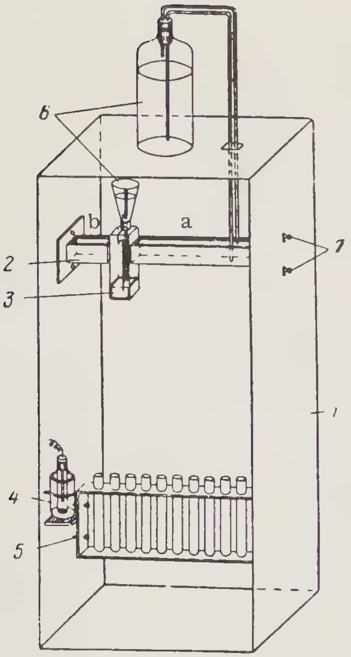

Fig. 1. - Diagram of apparatus for continuous electrophoresis (for key see text)

› the Pickles-Durrum apparatus (Block and urrum, 5), except for a number of im- ortant differences enabling it to be con- ructed under laboratory conditions. The pparatus consists of a wooden box 1, 430 x 70 x 910 mm, a vessel for the buffer solu- on 2, and the mixture to be separated 3, vo electrode chambers 4, and a stand con- ining 15 test tubes for collecting the frac- ons 5. The vessel for the buffer solution onsists of two parts, a and b, connected by small glass tube. The vessel containing the uid to be separated is placed between these vo parts, on the cathode side of center, nce the humic acids are a polyanion group id will shift to the anode side of center in e process of separation. The levels of the iffer and of the separation mixture are kept onstant by means of Mariotte tubes, c.

In working with this apparatus the mainten- ce of a constant level both for the buffer and r the separation solution is most important. the levels alter, the pressure of the buffer the strip will also alter and the strip will ift either to right or left, with the result at the fractions will also move to one side the other. Every effort must therefore made to see that the level of the fluid in both ssels is the same or that it is slightly higher the smaller vessel. This is done by means the regulating screws 7.

We used ordinary carbon electrodes instead the platinum electrodes used in the Pickles- urrum apparatus. Since carbon electrodes sintegrate during the work (particularly pidly at the anode) they are placed inside glass filters in order to prevent the disintegration products from falling on the paper. For this purpose the electrodes are fixed in rubber steppes, in which a hole is cut to allow for the escape of the gases (H_2 and O_2) formed during the electrolysis of the water; otherwise the gases would accumulate inside the glass filter, displacing the electrolyte so that the circuit would be broken and the instrument would stop working. The electrodes are placed in the glass containing the buffer solution, into which the lower ends of the paper sheet are lowered. With this method of voltage feed there is no risk that electrolysis products will fall on the paper sheet. The apparatus is set at a voltage of 400 ± 40 volts, a current of 4 milliamps, and a resistance of 100 kΩ.

A 1/30 M solution of double-substituted sodium phosphate with an ion strength of 0.1 and pH = 8.68 was used as the buffer solution. As the buffer has considerable ionic strength, a good deal of heat is generated with the passage of the electric current. This leads to intensive evaporation of water from the surface of the sheet, with the result that the concentration of the buffer solution changes. It is not possible, however, to use a solution of low ionic strength, since such a solution would have poor buffer properties. We reduced the amount of evaporation from the buffer solution by creating an atmosphere saturated with water vapors inside the chamber. This was done by fastening a sheet of filter paper wetted with water to the rear wall of the instrument (the end of the sheet being lowered into a vessel containing water) and closing the front of the chamber with a glass.

The humic acid separation effect depends a good deal on the quality of paper used. We used Leningrad slow-filtering chromatographic paper. It took 2 to 3 hours for this paper to become steeped with the buffer solution (that is for the front of the buffer to pass through the paper). The time depends on the level of the buffer in the vessels, a factor which also determines the rate of flow. Using the apparatus described we performed separation of humic acids separated from the soils described in Table 1.

The humic acids were obtained after decalcification with 0.1 n NaOH. The precipitates were twice filtered through the paper filter. A carbon concentration of 0.078% and pH 8.68 was established in the alkaline solution of the humate. The distribution of the humic acid took 3 to 4 days.

It was established from the investigations that: 1) humic acid is not an electrophoretically homogeneous substance; this can be seen visually, for the charts clearly show 2 zones, one gray, the other cinnamon-brown;

2) this division is particularly distinct in ultraviolet light; under ordinary light the cinnamon-brown tint strip hardly shows at all, but under ultraviolet illumination it becomes luminescent with a bright white light; the gray zone remains in the form of a dark strip;

3) both the gray and the cinnamon-brown strips extend for some distance in the electric

Table 1

Description of soils used for humic acid separation

Soil	Horizon and depth, cm	Texture-clay loam	Humus %	pH (salt)	Hhyd	S
					meq	
Podzol. Archangel Oblast'	A_2	Coarse	1,2	4,4	2,2	6,5
Sod-podzolic, excessively wet. Moscow Oblast'	0—10	Medium silty	3,1	4,0	9,9	5,5
Chernozem. Kamenni steppe	5—25	Medium	9,1	5,6	2,6	54,9
Red earth like, Sochi rayon	0—12	Fine	3,4	4,4	11,4	7,5
Crusty chestnut solonetz. Stalingrad Oblast'	0—7	Fine	2,3	5,4	1,1	21,5

Note: Comma represents decimal point.

field, indicating that the substances forming these strips include components of greater and lesser mobility; we should therefore speak of the separation not of chemically individual components but of groups of gray and brown fractions;

4) the electrophoretic charts for the humic acids obtained from different soil groups differ substantially from one another in regard to the shape, size, and color of the strips formed by the gray and brown fractions. In the chernozem, solonetz, sod-podzolic, podzol, and red earth-like subgroups, the strip formed by the gray fractions gradually becomes smaller and finally disappears altogether, whereas there is a corresponding increase in the size of the cinnamon-brown fraction strip.

As we had collected sufficient amounts of the individual fractions, of which there were 15, we were able to determine the optical density at wave lengths of 300-1600 mμ of the original humic acids and the fractions obtained from them, to measure the size of each fraction, to find the carbon concentration in them, and to calculate the carbon distribution by fractions. Our research confirmed that the Bouguer-Beer law can be applied both in the case of humic acid as a whole, and in the case of the individual fractions. The optical density was determined with an SF-4 spectrophotometer. All the humic acids and their fractions have a spectroscopic curve of identical character with peak absorption in the ultraviolet part, and minimum absorption in the 1000-1300 mμ region.

For the spectroscopic characteristics of the humic acids and their fractions we used the coloration factor $Q_{4/6}$ given by Welte (7). This factor depends not on the concentration of the humic acid but only on its nature.

Figure 2 shows the characteristics of the fractions in terms of $Q_{4/6}$. Fluorescence occurs in fractions above the boundary (we measured the fluorescence on a fluorometer) but not in those below this line.

Since the separation process took 3 to 4 days, during which the fractions may have shifted relative to their original positions, we shall confine ourselves to conclusions of a general nature.

1. All humic acids have a group character. This is indicated by the gradual, regular increase in the coloration factor in the series of fractions from 1 to 15 in all the humic acids.

2. Humic acids move to the anode, the greatest deviation from the vertical occurring in the case of fractions with a high $Q_{4/6}$ value. These are consequently the most mobile. It may be assumed that their mobility is due to their having a simpler structure.

If we assume that the molecular structure of humic acids becomes simpler with increase of $Q_{4/6}$ (since they become more mobile), we may take it that chernozem humic acids are among the most complicated fractions and red earth humic acids among the simplest.

3. The fluorescence boundary shows that

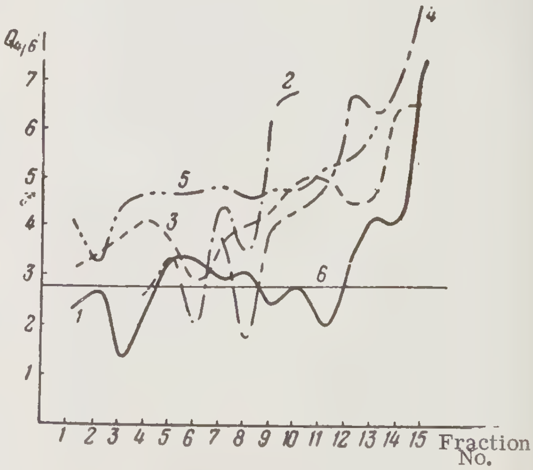

Fig. 2. - Change of $Q_{4/6}$ according to fractions. 1 - chernozem; 2 - chestnut-solonetz; 3 - sod-podzolic soil; 4 - podzol; 5 - red earth; 6 - fluorescence boundary.

nly chernozem humic acids possess non-
uorescent fractions. Humic acids of red earths
ave only fluorescent fractions, whereas humic
cids of other soil groups are intermediate be-
veen these two in this respect. The fulvic
cids show the most intensive fluorescence.

The humic acid characteristics depicted on
e graph indicate that the humic acids of dif-
rent soils form a continuous series of com-
ounds of gradually more simplified structure.

Conclusions

1. Separation of humic acids by electrophor-
sis bears out the view that soil humic acids
re not chemically distinct substances but a
roup of substances which have common struc-
ral characteristics but are not completely
lentical with one another.

2. It was established that chernozem humic
cids consist of fractions possessing low mo-
lity in an electrical field and that most of
ese fractions do not possess the property
fluorescence. Humic acids from red earths
re characterized by the predominance of
eadily mobile and fluorescent fractions.
umic acids of the other soils studied are inter-
ediate between these two extremes.

3. It was found that there was a relation-
ip between the fluorescent intensity and the
obility of the fractions in an electrical field.
can be said that the fluorescent intensity
creases in a series of humic acids from
ernozems to red earths; in other words, it
creases in proportion to the mobility of the
actions. The proportion of fluorescent
actions also increases in this direction.
ulvic acids fluoresce with particular intensity.

4. The results of the work described confirm
e literature data to the effect that classifica-
on of humic soil substances into groups of
lvic and humic acids is only provisional.
his classification cannot be explained in
rms of physical and chemical properties
a result of the molecular structure of these
cids.

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RED WEATHERING-CRUST SOILS OF ALBANIA

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The red soils in the Mediterranean area are often known as terra rossa. The term is a geological one which has long been current in the literature of soil science but which is given various meanings by different writers. Glinka (4) calls such soils red-colored and adduces certain information given by Dranitsyn (6) on the characteristics of the soils formed under the alfa steppe on the African continent. He writes: "to this group of soils belong the red earths of Spain, which we had occasion to observe continuously in the neighborhood of Salamanca and Valladolid, although it is open to question whether they are not old soils which have been converted in our own epoch into soils of the desert-steppe group."

Aleksandrova (1) classifies the colored clays of Transuralia (which are also predominantly red in color) as belonging to a group of laterite crusts on which gray forest and chernozem soils have formed in our epoch.

Dzens-Litovskaya (5) notes that: "red-brown soils approach brown earths most closely on the southern shore of the Crimea, in the Mediterranean climatic zone; higher up, under the beech forests, they are noticeably podzolized. Chernozem-like mountain-meadow soils develop on the terra rossa at Yayla. The soils developed on terra rossa in the Crimean steppe are poorly leached and carbonate and can be classed as red-brown carbonate chernozems.

Prasolov and Petrov (14) point out that: "in western Europe the terra rossa is sometimes represented by carbonate varieties in which the maximum $CaCO_3$ content is found in the top horizons and sometimes by carbonate-free leached soils containing various amounts of humus — as much as 10%-12%, or as little as little as under 1%. The terra rossa has no definite genetic profile in terms of which it could be placed in a series with the other (leached) soils of this region (the steppe and forest soils). In regards to red earths on terra rossa, it has still to be proved that these form under the recent climatic conditions of the Mediterranean countries." As we see then, these authors also note that materials of various kinds are classed together under the term terra rossa. Gerasimov (3) like other Soviet and foreign investigators, draws a distinction between recent and old red-colored limestone weathering crusts. He calls the former a terra rossa group of soils but regards the latter type of terra rossa as a subsoil of dry forest and shrub cinnamon-brown soils. Chukhrov (16) comes to the conclusion that the term terra rossa is a collective one and "covers all the red-colored earth formations which coincide with limestone." Ivanova and Rozov (7), who travelled through the south of France in 1956, also reached the conclusion that "the question of the terra rossa as recent, dry subtropical soils on limestones needs revision."

In a review of papers on soil genesis presented at the Sixth International Congress of Soil Science, Ivanova et al. (8) write: "since the recent climate in a number of the regions studied is relatively dry, the terra rossa are believed by many to be relict formations inherited from a warmer and wetter period in the past."

The term first appeared in the literature when the geology of Albania (Istria) was studied. Most authorities note a connection between these formations and carbonate rocks, (19, 23, 32, and others); some ascribe a marine (29) origin to them, others a volcanic origin (28, 30, 31), and others even an aeolian origin (18, 20).

In Regny's opinion (27) terra rossa is a deposit of alkaline solutions rich in iron, as well as of highly dispersed clays, in which case the amounts of iron present are fairly insignificant when climatic conditions are such that the red color can be imparted to the soil mass. Blanck (17) essentially develops Regny's idea.

Ramann (26) points out that so far the position of the red earth in the soil classification has not been established. In his opinion, terra rossa can be found under arid, semi-arid, and semi-humid climatic conditions. Klinge (23) believes it possible that terra rossa soils are forming at present, but is inclined to think that in the subtropics they predominate as relict soils.

Kubiena (24) distinguishes between 1) terra rossa; 2) its siallitic (silica-rich), stage; and 3) its allitic stage. We fully agree with e view of Kubiena and his students (25) that teritization and rubification (rubefizierung — reddening, occurring under conditions of rbonate removal) processes are at present king place in the tropics.

Mishunina (12), who worked for some years Albania, writes: "the presence of a red nt in the limestones and the presence of yers of red and red-brown shales is evidence the same source of a decomposition of igne- is rocks of basic and medium composition. In y view such deposits must be attributed to orough weathering of these igneous rocks, nder hot, wet climatic conditions, and the ubsequent removal of the products of this eathering to the littoral part of the basin." ishunina then does not consider it absolutely igatory to connect the red color of the wea- ering crusts with limestones or with carbon- e rocks in general. Our own observations lly bear out her conclusion that it is diffic- ılt to attribute the red color of the rocks in lbania (Istria) solely to their genetic connec- on with carbonate parent material. We re- ard the presence of red colored crusts in reas where there are hardly any carbonate ocks or none at all (Sakhalin, Transcarpathia, outh Sikhote-Alin' and many others) as further vidence of this.

Even from this far from complete survey of e literature on "terra rossa" it is obvious at the term is a very general, collective ne, used to designate the red colored weather- g crusts of rocks, which differ in composi- on and age, as well as their derivatives. It cludes both recent formations (cases where ere has been an infiltration of substances con- ining certain amounts of highly dispersed on sesquioxides which cause them to have a eddening effect [9]) and old formations, ith the result that the area over which "terra ossa" soils are found is very large and far om uniform as regards contemporary cli- atic conditions; nor, of course, are the eathering crusts classed together under this rm uniform in regard to chemical composi- on. The only feature they have in common is e red tones of their color, which are due not much to the quantity as to the nature of the on forms present in them.

In view of the foregoing considerations, erefore, we believe that the use of the term rra rossa as a name for a soil group is quite acceptable. It can be retained in the litera- re to denote soil genera belonging to various oups.

This contention is supported by the data ven below. We shall begin with a morphologi- l description of various groups of soils rmed under various bioclimatic conditions areas where red colored weathering crusts e common.

Profile 534. Light brown red colored soil th elements of weak gleyzation (2) in the anscarpathian Oblast' of the Ukrainian R, near the town of Mukachevo. The soil formed on deluvial red colored alluvia, e weathering products of the basalts and desites of Mt. Chervonnaya. Height, 150 . Southwestern slope, 5°. Apple orchard. The ground was previously occupied by an oak-beech forest. Fairly thick grass cover.

A$_1$ 0—17 cm. Darkish-reddish-brown fine clay loam. Fairly loose, with coarsely granular and fine nutty structure. Many plant roots. Transition to next horizon comparatively abrupt.

A$_2$ 17-30 cm. Darkish-reddish-brown, somewhat lighter than the A$_1$ horizon. Fine clay loam. Slightly compacted. Granular structure. Occasional roots. Isolated compacted rock rubble. Transition to AB$_1$ horizon comparatively gradual.

AB$_1$ 30-51 cm. Grayish-reddish-brown compacted fine clay loam with blocky to fine nutty structure. Occasional patches of small weathered rubble. Transition to B$_1$ horizon fairly abrupt.

B$_1$ 51-67 cm. Brownish-red fine clay loam, more moist than the horizons above it, compacted. Blocky to vaguely nutty structure. Occasional basalt and andesite rubble. Transition to B$_2$ horizon comparatively gradual.

B$_2$ 51-99 cm. Reddish-brown fine clay loam, with occasional dark bluish spots of gleyzation. Blocky structure. Transition to B$_2$G horizon comparatively gradual.

B$_2$G 99-132 cm. Brownish dark bluish fine clay loam with reddish spots. Blocky structure. Transition to CG horizon gradual.

CG 132-150 cm. Dark bluish rusty fine clay loam. Coarsely blocky structure. Many manganese phenocrysts. Does not effervesce from HCl.

Profile 303. Albania. Cinnamon-brown leached soil on deluvia of red colored weathering crusts. 7 km southeast of Peshkopiye. Altitude 860 m. Slope exposed to the east, gradient 5°. Overgrown with shrubby oak (*Quercus conferto*) and thick clumps of fern (*Pteris aquilina*); some *Heleborus adorus* and other plants.

A' 0-12 cm. Light brown fine clay loam. Compacted. Blocky-granular structure. Transition to A'' horizon comparatively abrupt.

A'' 12-25 cm. Looser, more roots, better structure. Transition comparatively abrupt.

AB$_1$ 25-43 cm. Brownish-reddish coarse clay of granular-blocky structure. Some large live and dead roots. Comparatively sharp transition to next horizon.

B$_1$ 43-69 cm. Brown-red clay (compact). Blocky and small nutty structure. Transition to next horizon gradual.

B$_2$C 69-95 cm. Coarse clay, redder than B$_1$ horizon. Many neoformations (manganiferous pisolitic concretions).

Profile 267. Albania. Cinnamon-brown red colored soil with elements of magnesial solonetzization, along Skodar-Puko railway, altitude 480 m. Slope to southern exposure hollow, gradient 14°. Overgrown with shrubs, mainly oak (various species). Predominant grasses. The surrounding mountains are composed of ophiolitic pyroxene.

A_f 0-12 cm. Darkish brownish-red fine clay loam. Some mycelia fungi. Good granular and fine nutty structure. Many plant roots and coarse compact rock rubble. Abrupt transition.

AB_{1f} 12-35 cm. Differs from above horizon in color and in possessing more massive structure. Red tones less common. Transition to B_1 horizon abrupt.

B_{1f} 35-49 cm. Brown-red fine clay loam with massive-nutty structure, very compact. Many plant roots and rock rubble. Transition to B_2 horizon abrupt.

B_{2f} 49-80 cm. Heavily weathered rock with admixture of fine clay loam in the fine earth with red color. Percentage composition of rock: pyroxene, 20; bastite, 15; serpentine, 40; spinel, 15; magnetite, 10.

Profile 62. Albania. Gray-cinnamon-brown, red-tinged, along Qimar-Saranda railway; altitude 50 m. Between mountain depression. The profile is on a western slope, gradient 5°. Steppe vegetation predominates: Flomis fruticosa and individual bushes of Lugianosa Inula viscosa, Picus amigdalifolium and others. Among the grasses Trifolium nigrescens, T. araria, Eringium compestre, Craefilus sp., and others.

A_f 0-33 cm. Brick red fine clay loam, very compact. Poorly developed fine granular structure. Contains many roots of plants and small rock fragments. Transition to next horizon comparatively abrupt.

ABf 33-61 cm. Dark red fine clay loam, granular structure, fresh. Some individual plant roots and coarse limestone rubble. Comparatively abrupt transition to Bf horizon.

B_f 61-110 cm. Same color as AB_f horizon, clay, fresh. Contains much limestone rubble. Percentage composition of rock microsection: calcite, 40; clay material, 60.

The foregoing morphological descriptions of soil profiles formed of red-tinged weathering crusts under various bioclimatic conditions reveal substantial differences along with certain similarities.

A characteristic feature of the brown forest soil developed in the oak-beech forest zone of Transcarpathia, and now lying under an apple orchard area is the r elatively clear differentiation of the various layers of the profile. There is a distinct humus horizon, then a middle part of the profile showing slight signs of gleyzation and finally the somewhat more heavily gleyed lower part of the profile. In this profile the ground waters are very deep and the gleyzation of the lower part of the profile is due to the flow and stagnation of surface waters along the slope. Where there is no such flow of surface waters, only the BG horizon (pseudo gley) is gleyed. This is highly typical of gray forest soils in the western regions of the Ukrainian SSR and is also very common in the brown forest soils in western Europe.

Profiles 303 and 267, situated in the dry forest and shrub belt in Albania, are characterized by soils of the cinnamon-brown group. Despite their relatively similar formation conditions, these profiles differ appreciably from each other by reason of the dissimilar nature of the soil soil-forming parent materials. The soil in Profile 267 has been formed on a red-tinged weathering crust of ophiolitic pyroxenes and contains an appreciable amount of magnesian minerals. Profile 267 is on a slope facing a hollow enclosed by mountains. This gives grounds for the assumption that the soil in question has passed through a stage of excessive wetting. Profile 303 is a typically Albanian soil of the cinnamon-brown group with a barely distinguishable humus horizon which is appreciably compacted and a B horizon in which clay has accumulated, without any signs of gleyzation. This soil has formed on red clay deluvia. Finally, Profile 62, situated on the gentle slopes of a coastal valley, has a soil of the gray-cinnamon-brown group under maquis vegetation. The profile of this soil is very poorly differentiated and the reddish tones in the color of the weathering crust emerge very distinctly even in the humus horizon.

A red tinge in the profile is a common feature in the morphology of all these profiles.

Analysis figures are shown in Table 1. It should be noted that small limestone fragments passed through the sieve with 1-main opening with the result that high pH values were obtained particularly for the water suspension. This also occurred in regard to exchangeable cations (especially calcium).

The very wide range of pH variation is striking. The soil profiles formed on red-tinged weathering crusts of calcareous parent material which has a neutral or slightly alkaline reaction are themselves neutral or slightly alkaline owing to the leaching carbonates from the top horizons. The reaction of the parent material and the soil on weathering crusts of carbonate-free igneous rocks is acid. Here the pattern is reversed: biological accumulation of cations takes place in the top horizons and the reaction in them becomes less acid. The most acid soils in the profile are the lowest horizons, which apparently become more acidified in the process of soil formation, losing their cations to the top horizons through transport by vegetation.

Comparing the data for the humus content with the morphological picture of the soils (the color of their top humus-accumulative horizons), we find, paradoxically, that the red is brightest in the humus horizon of the brown forest soil and less bright in the gray-cinnamon-brown soil. The analyses, however, established that the humus amount in the top horizons of both soils is very similar. This indicates that the qualitative composition of the humus in these two soil groups is different.

The figures for the fraction composition of the humus in the gray-cinnamon brown soil

Table 1

General analysis of red-colored soils[a]

[a] The analyses were performed in the laboratories in the Geographic Large-scale Cartography Division of the Soil Institute (USSR Academy of Sciences) and in the Central Laboratory of the USSR Board of Geology

rofile number and parent material	Horizon	Depth, cm	Losses on ignition at 900°C	Hygroscopic water, %	pH		C, %	Humus (Tyurin's method)	Nitrogen (Kjeldahl's method)	C/N ratio	Acidity, meq (Sokolov's method)		
					Water	Salt		%			H	Al	Al as % total acidity
Light brown forest red-tinged gleyed. Transcarpathian Oblast' of the Ukrainian SSR													
534. n peridotite and andesite deluvia	A_1	0—5	—	2,5	5,71	2,96	1,85	3,2	0,18	10,0	—	—	57
	A_2	20—25	—	3,0	5,80	4,94	0,75	1,3	0,14	—	—	—	67
	AB_1	40—45	—	2,6	5,69	4,71	0,70	1,2	0,09	—	—	—	78
	B_1	70—75	—	2,8	5,31	4,45	0,34	0,6	—	—	—	—	81
	B_2	100—105	—	2,6	5,43	4,14	0,29	0,5	—	—	—	—	73
	C	140—145	—	3,4	5,06	4,10	0,12	0,2	—	—	—	—	87
Cinnamon-brown red-tinged. Albania													
303. n red clay deluvia	A	0—10	8,8	1,6	5,81	4,75	1,48	2,6	0,15	10	0,02	0,05	71
	AB_1	30—35	6,9	1,9	5,44	4,53	0,10	0,1	—	—	0,04	0,42	91
	B_1	55—60	8,0	1,8	5,10	4,06	—	0,05	—	—	0,03	1,96	98
	B_2C	90—95	8,1	1,8	5,10	4,06	—	0,05	—	—	0,02	2,19	99
Cinnamon-brown red-tinged with magnesial solonetzization. Albania													
267. n ophilitic pyroxene weathered and leached deluvia	A_f	0—10	21,2	3,5	7,6	6,5	5,3	10,9	0,43	13	0,05	0,12	70
	AB_{1f}	20—25	13,8	3,5	6,8	6,1	1,0	3,3	0,13	8	—	—	—
	B_{1f}	40—45	7,2	4,5	6,7	6,1	—	1,1	—	—	0,10	0,12	54
	B_{2f}	75—80	15,9	5,5	7,7	6,1	—	0,9	—	—	0,09	0,12	57
Gray-cinnamon brown red-tinged slightly leached. Albania													
62. n weathered and leached limestone deluvia	A_f	0—10	8,7	2,1	7,18	6,29	1,96	2,2	0,15	13	—	—	—
	AB_f	45—50	12,3	3,6	7,35	6,74	1,34	1,1	0,10	13	—	—	—
	B_f	100—110	12,4	3,8	7,66	6,83	—	1,0	—	—	—	—	—

ote: Comma represents decimal point.

able 2) show that fulvic acids predominate. he ratio of C in (humic acids) to C in (fulvic cids) in the organic matter of these soils is ly 0.2-0.3, or even lower than in sierozems d red earths. This may well be connected ith the suppression of bacterial flora which curs in Albania both during the rainy period d during periods of severe drought; at these mes it is mainly fungi and actinomycetes (15) hich decay plant residues, yielding fractions primarily light colored organic acids.

So high a proportion of light colored com- ounds naturally makes the humus of these oils barely noticeable to the naked eye. Unrtunately we have no values for the fractional omposition of the humus in the brown forest il profile. The information available in the literature, however, indicates that a high humic acid content is a typical feature of such soils and that the C in (humic acid to C in fulvic acid) ratio in them is usually near to unity. The humus distribution along the profile of these two soil groups also differs. In the brown forest soils the decrease in humus with depth occurs fairly abruptly and this also makes for a morphologically very distinct humus horizon in the profile. In the gray-cinnamon brown soils the humus decreases very quickly with depth. Even at a depth of 110 cm (Profile 62) a relatively high humus content can still be detected (1.0%). We are inclined to attribute this to the mobility of the humic acids -- to their capacity for flowing along the profile of the gray-cinnamon brown soil. This phenomenon is not observed in the

Table 1 Continued

Adsorbed cations, meq per 100 g of soil (Gedroyt's method)					Degree of cation unsaturation	Degree of magnesial solonetzization	Mobile compounds, mg per 100 g of soil				Color of ignited soil
Ca^{++}	Mg^{++}	$Ca^{++}+Mg^{++}$	H^{+}	$Ca^{++}+Mg^{++}+H^{+}$	%		Fe (Kirsanov method)	P_2O_5 (Machigin method)	K_2O (spectroscopically)	N (Tyurin-Kononova method)	
The same											
4,45	2,71	7,16	0,61	7,67	8,0	35	10,2	Trace	5,6	9,3	Brown-red
3,59	1.35	5,44	0,82	6,27	11,5	25	9,6	"	3,5	7,9	"
2,56	2,14	4,70	1,03	5,73	18,0	46	7,3	"	2,8	—	"
2,56	2,07	4,63	0,65	5,08	13	45	7,8	"	3,9	—	Brownish-red
2,18	2,44	4,62	0,82	5,44	15	53	7,7	"	—	—	"
3,34	4,44	7,78	1,82	9,60	19	57	7,7	"	—	—	"
The same											
7,55	1,97	9,52	0,20	9,82	2	21	0,7	0,27	15,0	—	Light brown with red tinge
3,15	2,96	6,11	0,56	6,67	7	48	3,0	—	—	—	Very slightly brown
3,05	2,63	5,68	1,60	7,28	25	46	2,8	—	—	—	Brownish-red
3,45	2,39	5,84	2,16	8,00	27	41	2,8	—	—	—	"
The same											
10,85	20,48	31,33	0,40	31,73	1	66	4,2	0,4	14,0	44,21	Brown-red
4,15	23,93	28,08	0,20	28,28	1	85	25,0	0,4	11,0	—	Reddish purple
3,60	26,24	29,84	0,20	30,04	1	87	42,0	—	—	—	"
3,50	44,6	48,16	0,12	48,28	Trace	93	50,0	—	—	—	"
The same											
12,10	0,41	12,50	0,40	12,90	3	Trace	0,6	Trace	8,8	—	Brownish-reddish
33,20	0,74	33,94	0,12	34,06	<1	"	8.4	4,8	12,2	—	Very slightly redder
28,80	1,80	30,60	None	—	—	"	None	—	—	—	"

brown forest soils, apparently because the presence of free sesquioxides saturated with organic compounds in the profile prevents it.

Soils of the cinnamon-brown group occupy an intermediate position between the brown and gray-cinnamon brown soils, but are nearer the former.

The profile of cinnamon-brown soil which has developed on magnesium-rich parent material, and has apparently passed through a meadow stage owing to its position in the relief, must be treated separately (outside this series of group comparisons). This soil is an example of the possible range of variations in the processes of soil formation on red-tinged crusts of varying composition, within the limits of a single bioclimatic zone, and where the degree of wetness varies owing to the redistribution of moisture through the relief.

The values for base unsaturation in the soils formed on parent material with an acid reaction present an interesting pattern. In the brown forest soil base unsaturation is more or less uniform throughout the profile except in the topmost horizon, where it sharply decreases owing to the biological accumulation of cations. On the other hand, in the cinnamon-brown soil formed on analogous clay, or at any rate fairly similar parent material, unsaturation is high in the lower horizons and low in the top horizons.

The difference between the profiles, however, in regard to the degree of unsaturation is not due to biological accumulation of bases, since the amount of adsorbed calcium and magnesium is roughly the same throughout the whole profile (except for the topmost horizon); it is due rather to the appearance of appreciable quantities of adsorbed hydrogen (Gedroyts) in the lower part of the soil profile. We are inclined to explain

Table 2

Analysis of organic matter in red-colored soils of Albanian[a]

[a]The analyses were performed in the soil biochemistry laboratory in the Soil Institute of the USSR Academy of Sciences, under the direction of M. M. Kononova

file o.	Hori-zon	Depth, cm	Total C as percentage of air-dry soil	Humus (C x 1.73)	Percentage of total C					Humic acids C / Fulvic acids C	Mobile humic acid as percentage of total C
					Decalcified C	Humic acid C		Total humic acid C	C residue in soil after extraction of humic acids		
						Alkaline extraction fraction after decalcification	Total humic acids				
7	A_f	0—10	16,35[a]	10,91	15,6	15,9	20,2	22,2	35,6	0,91	9,8
	AB_{1f}	20—25	1,94	3,34	12,4	12,4	15,0	25,7	33,5	0,58	7,2
2	A_f	0—10	1,28	2,21	20,3	6,3	8,6	24,2	35,9	0,35	8,6
	AB_{1f}	15—50	0,64	1,10	15,6	4,7	6,3	29,7	39,1	0,21	None

The values in this column are taken as equal to 100%

ote:Comma represents decimal point.

pearance in the lower horizons of the mon-brown soils as the result of the ence in these soils of the aluminum oxides are bound up with the processes of slight zation. This would seem to grounds e supposition that this process is still ring in the cinnamon-brown red-tinged one to this day, if only to a very slight t. The hypothesis, however, must be ied on the basis of a larger amount of al material.

conclusion let us examine the cinnamon- magnesial solonetzic soil. As the ses show, this soil differs sharply from her profiles analyzed in regard to every f the indices. It contains more humus; esium predominates in its adsorption lex; the lower horizons are rich in e forms of iron. The large quantity of hroughout the profile of this soil is ng, whether we look at the total chemical sis or at those for the colloidal clay frac- Table 3).

ermal analysis performed in the soil alogy laboratory of the Soil Insti- Academy of Sciences, USSR (compu- s by Ye. A. Shurygina), showed that omposition of the clay minerals along rofile for No. 267 is distinguished by uniformity and is similar to non- e, except for the top horizon which s hydrophilous and contains fewer admixtures.

find then that the non-uniform composi- f the red-colored weathering crusts, panied by a certain difference in the regime, leads to the formation of edly different soils.

Conclusions

1. Red-colored weathering crusts can form both on silicate and on carbonate rocks and also, apparently, on all rocks formed under other climatic conditions (with laterite or near-laterite weathering).

2. Red-colored crusts must be subdivided into acid, carbonate, and magnesial, according to the nature of the material from which they have formed. This distinction makes a great deal of difference to the nature of the soils formed on them.

3. Soils of various groups form on old red-colored crusts, according to the various bioclimatic conditions prevailing today. These soils have a reddish tone in their coloring and are therefore often covered by the blanket term terra rossa in the literature.

4. The specific character of soils developed on red-colored crusts varies according to the soil group and the properties of the weathering crust. It is therefore essential to assess this individual characteristic in each soil group and determine its place in the classification.

5. The majority of red-colored crusts seem to have originated from laterite soils or near-laterite formations and are therefore poor in so powerful a coagulator as calcium.

Received February 6, 1960

Table 3

Total chemical analysis of red-colored soils and their colloidal fractions as percentages of ignited and carbonate-free sample[a]

Profile No.	Horizon	Depth, cm	Molecular ratios			CO_2 (%) (Knopp method)	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	TiO_2	P_2O_5	CaO	MgO	MnO	Na_2O	K_2O	SO_4	Total	Adsorp. cap. (Gedyrots method) meq	Humus (%) (Tyurin method)
			$\frac{SiO_2}{R_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{Al_2O_3}$																
									Soil												
267	Af	0—10	2,75	5,92	7,70	—	46,35	32,46	21,28	10,41	0,65	0,12	3,46	16,87	0,45	0,53	0,70	0,70	101,18	—	—
	AB_1 F	20—25	2,06	5,28	6,73	—	44,53	34,40	22,34	11,55	0,46	0,07	3,11	17,67	0,41	0,25	0,33	0,59	101,31	—	—
	B_1f	40—45	2,55	4,93	6,73	—	44,26	35,61	24,09	11,02	0,46	0,04	2,80	17,48	0,33	0,16	0,23	0,17	100,97	—	—
	B_2f	75—80	3,29	5,64	7,90	—	47,16	33,70	23,24	10,03	0,39	0,04	2,59	16,27	0,34	0,14	0,21	0,45	100,86	—	—
	Ophilitic pyroxene parent material		5,50	7,70	19,25	—	46,13	18,27	14,07	4,18	Trace	0,02	2,17	34,15	0,21	0,03	Trace	0,73	101,69	—	—
									Colloidal clay fraction												
267	Af	0—10	1,99	3,61	4,42	—	41,65	47,95	31,13	15,99	0,55	0,23	0,66	10,20	0,04	0,13	0,54	0,63	101,75	50,08	7,63
	AB_1f	20—25	1,85	3,07	4,66	—	41,01	50,99	35,33	14,97	0,57	0,11	0,53	8,07	0,03	0,11	0,37	0,56	101,63	54,90	2,34
	B_1f	40—45	1,83	3,00	4,69	—	41,16	52,58	36,80	15,03	0,64	0,99	0,33	6,26	0,03	0,08	0,26	0,27	101,03	61,03	1,92
	B_2f	75—80	2,29	3,96	5,45	—	47,06	47,00	31,72	14,57	0,49	0,21	0,38	6,31	0,03	0,09	0,30	0,58	101,74	75,56	1,42
62	Af	0—10	2,64	13,57	3,27	—	55,44	40,61	10,80	28,42	0,91	0,48	0,36	2,02	0,08	0,17	2,00	0,37	101,01	44,82	3,37
	ABf	45—50	2,47	12,33	3,09	—	54,07	42,94	11,59	29,70	0,99	0,56	0,36	1,48	0,17	0,11	1,93	0,20	101,26	42,98	1,37
	Bf	100—110	2,50	12,53	3,13	—	54,21	42,36	11,50	29,35	1,01	0,50	0,35	1,60	0,17	0,11	1,86	0,09	100,75	48,03	1,23
	Limestone parent material		59,0	159,0	79,0	23,35	97,19	4,69	2,23	2,10	Trace	0,31	Trace	1,13	0,19	0,28	0,31	0,56	104,35	—	—

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BIOCHEMICAL ACTIVITY OF A DARK GRAY FOREST-STEPPE SOIL UNDER VARIOUS FOREST PLANTATIONS

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Although it is generally accepted that biochemical reactions are of great importance in soil processes, little study has so far been devoted to the relationship between the biochemical properties of a soil and the type of vegetation growing in it.

In regard to the biochemical activity of a soil the rhizosphere zone is of particular importance. The biochemical processes originating in it influence the entire soil mass in which the plant root system is formed. Among the principal factors determining the biochemical activity of the rhizosphere in forest soils we may mention the genetic group to which the soil belongs, the plant climate, the composition of the vegetation, the structure of the root system, root secretions, forest litter decay products, the amount, composition, and activity of microorganisms and so forth. All these factors determine the type of biocoenosis in the rhizosphere.

In plantations where the root system is fibrous, given a favorable soil temperature, the level of biochemical activity and of nitrification processes is rather high (Table 1). In plantations of the European ash the total biochemical activity of a dark gray clay loam is 33.3%, and the nitrification capacity 53.5% higher than under a canopy of recent oak plantation. The root system of elms is also fibrous, but the biochemical activity of a dark gray soil under this type of cultivation differs from that under ash and is similar to that of the same soil under late flowering oak. These differences are due in part to the specific action of the ash, elm, and oak on the biochemical activity of the soil.

A slightly sod, strongly podzolic soil under rows of birch in a mixed pine-birch plantation proved biochemically more active than the same soil under rows of pine (Table 1). Here again, we must attribute the difference to the specific influence of the pine and birch rhizosphere and its biocoenoses.

In investigating the rhizospheric biocoenoses and their influence on soil, it is worth studying the activity of the enzymes formed in the soil. In this case the enzymes can be one of the indices of the biochemical activity of the soil. Soil enzymatic activity has long attracted the attention of investigators. Liebig in 1844 drew attention to the catalytic properties of soil. Many investigators (8, 15, 20, 26, 27) have understood how important these properties of a soil are for its fertility. In 1951 Kuprevich (12, 13) suggested a method for determining the enzymatic activity of soil. This method yielded results that could be satisfactorily reproduced and has been used by later investigators to study the relationship between a soil's enzymatic activity, on the one hand, and its genesis (2, 22), melioration (16), the agricultural practices employed (4, 1) and so forth.

There is great value in discovering how the enzymatic activity of a soil is related to various forest types. Such investigations can give us a more thorough understanding of how the tree composition in a plantation influences the formation of forest soil fertility.

Using the method suggested by Kuprevich (13), we studied the activity of catalase and invertase in the profile of a dark gray silty clay loam on loess under various plantations. The enzymatic activity was determined on fresh soil samples. These were composted for the purpose of determining the total biochemical activity of the forest litter and of the soil, and the capacity of the soil for ammonification and nitrification.

The plantations under study are growing in compartments 40 and 45 of the Krasnyanskoye forest area in the Trostyanetskiy forest, Suma Oblast' (Ukrainian SSR). The plantations are situated in a level watershed with a uniform soil, where the agricultural practices are the same. The areas for comparison are directly contiguous with one another. Their assessment indices and growth history have been described in detail by Gurskiy (6, 7); the soil conditions have been described in detail by us (24, 25).

The soil studied is under a canopy of late flowering oak, Norway maple, European ash, small-leaf basswood, and elms planted in unmixed rows, and of mixed plantations of these trees (plantings in rows, with a different type of tree forming each section of the row). The plantation is 29 years old. The same soils had been studied under a canopy of spruce and oak plantations in 1893 (age 63 years). These spruce-oak plantations were in rows. Where early oak is mixed with spruce, the spruce

Table 1

Influence of different types of trees on the biochemical activity of soil

Soil	Crop	Depth, cm	Amount of fine roots (in g) in 2-25 cm layer[a]	Soil temperature at 10-cm depth on Sept. 19, 1956 (in degrees)	Total biochemical activity of soil, mg CO_2, absolute dry soil, per hour		Maximum intensity of nitrification, mg N, absolute dry soil			
							May		October	
					mg/kg	%	mg/kg	%	mg/kg	%
Dark gray clay loam slightly podzolic on loess	Late flowering oak, 29 years old	3—20	120,3	9,9	2,4	100,0	28,0	100,0	13,5	100,0
	Norway maple, 29 years old	»	183,9	8,9	2,9	120,8	26,2	92,8	17,4	128,8
	Small-leaf basewood, 29 years old	»	186,2	9,0	2,7	112,6	28,9	103,2	13,2	97,7
	European ash, 29 years old	»	204,3	10,4	3,2	133,3	43,3	153,5	16,5	122,2
	Elm, 29 years old	»	236,2	10,0	2,5	104,1	27,7	93,9	12,7	94,1
Dark gray clay loam slightly podzolic on loess	Oak, 63 years old	»	—	11,8	2,5	100,0	53,2	100,0	35,8	100,0
	Spruce, 63 years old	»	—	10,2	1,6	64,0	48,7	91,5	48,2	137,4
Slightly sod strongly podzolic, coarse clay loam on excessively leached moraine	Pine-birch, 15 years under pine row	2—15	None	—	2,4	100,0	5,24	100,0	2,4	100,0
	Pine-birch, 15 years under birch row	»	"	—	3,1	129,1	5,54	105,7	3,8	158,0

[a] From Gurskiy (7).

Note: Comma represents decimal point.

ops out of the plantation after 35 to 40 years, if it is mixed with late oak, the oak falls of the plantation. At present the different rts of this plantation have taken the form of ensive rows of almost unmixed oak or spruce, der which a second story of the elms has med (5, 24).

The catalase activity in the top (5-10 cm) er of the dark gray soil under the 29-year- late oak and its main associate species pends on the season of observation and the e of tree forming the canopy of the planta- n. In May the value varies, under different es of tree, between 205.3 and 175.5 ml O_2/ g soil, and in September between 162.8 and .7 ml O_2 per 100 g of soil. The value for y is lowest (137.4 ml O_2) for the soil under uce canopy, the value for September is est (126.6 ml O_2) for the soil under the year-old early oak (see Table 2).

There is an over-all pattern in the activity he enzymes in the profile of the dark gray under the various types of forest canopy, quantitatively it is determined by the nposition of the plantations and their rhizo- ere (Tables 2, 3, 4).

Invertase is distinguished by high activity in forest litter; the mineral layers of the soil display less invertase activity. Both catalase and invertase activity is highest in the soil layers immediately under the litter (5-10 cm), that is, the layers with the highest concentration of fine roots. At a depth of 15-25 cm the enzymatic activity of the soil is already notably lower than in the 5-10 cm layer. In the deeper layers (50-60 cm) the soil catalase activity usually declines by a factor of 1.5 to 2. No invertase activity could be detected in September at depths of 20-30 cm and 50-60 cm under the oak, elm, and spruce canopies (Tables 3 and 4). Catalase activity in September is less than in May. Conversely, invertase enzymatic activity in the top horizons is higher in September than in May.

The seasonal dynamic activity of catalase and invertase is most pronounced in the soil trees which have a very well developed fibrous root system (Norway maple, European ash, and the small-leaf basswood), but less marked under the elms, although these trees do have a well developed fibrous root system.

The soil areas under the various types of

Table 2

Catalase activity in profile of dark gray silty clay loam under deciduous plantations of varying composition, in mg O_2 per 100 g abs. dry soil (1956 values, 5 minute exposure)

Vegetation	Depth, cm	In May		In September	
		Soil moisture, %	Catalase	Soil moisture, %	Catalase
Late flowering oak	5—10	23,83	185,0	24,42	158,7
	15—20	20,13	147,7	18,06	128,1
	25—35	17,57	143,1	15,59	111,3
	50—60	11,37	31,2	17,57	112 8
Norway maple	5—10	23,69	175,5	27,20	168,0
	15—20	19,59	161,6	23,29	140,2
	25—35	18,69	142,5	17,72	112,9
	50—60	18,62	82,6	15,49	59,1
European ash	5—10	26,32	176,4	23,39	150,8
	15—20	24,46	162,0	25,00	153,3
	25—35	22,50	162,5	18,14	113,5
	50—60	18,14	72,0	17,42	39,9
Small-leaf basswood	5—10	24,67	183,1	21,79	136,7
	15—20	23,11	178,1	14,63	131,1
	25—35	17,44	150,2	14,65	120,6
	50—60	13,33	105,2	14,25	66,4
Elms	5—10	26,02	182,4	26,94	162,8
	15—20	22,84	162,9	17,55	133,3
	25—35	18,09	132,9	14,03	110,5
	50—60	18,77	63,9	16,74	63,4
Mixed "section" plantings	5—10	26,00	205,3	23,58	147,8
	15—20	22,14	183,6	14,41	148,3
	25—35	17,34	147,5	13,77	133,3
	50—60	18,94	79,0	12,63	71,0
1893 spruce-oak (spruce remained with second story of elms), compartment 45	5—10	22,78	137,4	24,79	147,5
	15—20	20,99	151,8	25,49	146,3
	25—35	26,25	146,3	18,15	103,8
	45—55	12,84	106,7	17,53	99,4
1893 spruce-oak (oak remained with second story of elms), compartment 45.	5—10	25,51	194,6	24,99	126,6
	15—25	19,93	177,3	22,76	130,7
	25—35	18,72	158,7	16,83	87,7
	45—55	18,27	95,4	16,79	88,9
1893 oak-maple, compartment 45	5—10	25,90	191,5	25,71	154,8
	15—20	20,85	179,3	22,41	141,6
	25—35	18,75	152,5	15,76	129,4
	45—50	18,40	110,2	16,50	70,6

Note: Comma represents decimal point.

deciduous plantations were listed in order of decreasing catalase and invertase activity during the different observation periods. The order does not coincide in the two periods.

May 1956: a) catalase: late oak, small-leaf basswood, elms, European ash, Norway maple; b) invertase; Norway maple, European ash, oak, elms, small-leaf basswood.

Table 3

Invertase activity in litter and dark gray soil under plantations of various composition in the Krasnyanskoye forest, g of invert sugar per 100 g abs. dry soil

Horizon	Depth, cm	Depth, cm		Norway maple		European ash		Small-leaf basswood		Elm		Mixed "section"	
		V	IX	V	IX	V	IX	V	IX	V	IX	V	IX
V	0—3	35,50	36,20	31,33	25,45	23,53	23,39	38,35	29,10	22,00	26,29	40,20	23,75
A_1	5—10	0,58	0,85	0,75	1,00	0,66	1,26	0,50	1,07	0,52	0,61	0,48	1,26
A_2	20—30	0,37	0,27	0,31	None	0,22	0,26	0,15	0,15	0,9	0,44	0,23	0,10
${}_1$—A_2	50—60	0,31	None	0,31	"	0,16	0,11	0,09	0,08	0,04	None	0,26	0,24

te: Comma represents decimal point.

Table 4

Invertase activity in litter and dark gray soil under plantations of various composition in the Krasnyanskoye forest, g of invert sugar per 100 g abs. dry soil. 1956 values

Horizon	Depth, cm	1893 oak with second story of maple and elm, compartment 45		1893 oak with spruce; oak remaining with second story of elm, compartment 45		1893 oak with spruce, spruce remaining with second story of elm, compartment 45		1893 oak with spruce, oak remaining, compartment 28		1893 spruce with European elder underbrush	
		V	IX	V	IX	V	IX	V	IX	V	IX
V	0—3	33,30	25,25	48,55	29,43	25,15	12,30	29,06	29,92	15,25	12,50
A_1	5—10	0,51	0,59	0,40	0,41	0,46	0,34	0,36	0,80	0,37	0,43
A_2	20—30	0,03	0,14	0,15	0,27	0,09	0,15	None		0,19	0,16
A_1—A_2	50—60	0,09	None	0,31	0,06	0,07	0,03	"		0,03	0,18

ote: Comma represents decimal point.

September 1956: a) catalase: Norway ple, elms, late oak, European ash, small-f basswood; b) invertase: European ash, all-leaf basswood, Norway maple, late , and elms.

It follows that the seasonal dynamic activity he soil enzyme is connected with the bio-logical characteristic of the trees forming plantation and varies at different observa- periods.

An interesting point is that the catalase invertase activity in the soil in May is her under the mixed "sectional" planta-s than under the pure plantations of their nponent trees. The total yield of the former lso higher than that of the pure stands. catalase and invertase activity in the soil he 63-year-old oak plantation is low in nparison with that of the 29-year-old oak ntation. This is probably due to differences he total activity of the root systems and rhizospheric biocoenoses in the two plan-ons.

The forest litter and top soil horizons er the spruce cover show less invertase and catalase activity in May than the forest litter and soils under oak of the same age (Tables 2 and 4).

The kinetics of the soil catalytic reaction also varies with the type of plantation and with the season, (see Fig. 1). This indicates that catalase is not uniformly active in soil under a canopy of forest plantations of varying composition. In some cases, as for example in soil under Norway maple, the catalytic reaction has almost completely ceased by the end of the second minute; in the soil under spruce on the other hand, reaction proceeds slowly throughout the whole observation period. It would seem then that catalase in soil under Norway maple is in a freer and more active state than catalase in soil oak and especially spruce. It is difficult to see why the enzyme behaves in this manner. The reason may be associated with the special character of the microaggregate composition of the soil under the various trees studied.

The enzymatic activity of the forest litter in the plantations under study can be judged from the invertase activity in them. This is in most cases higher in the deciduous litter

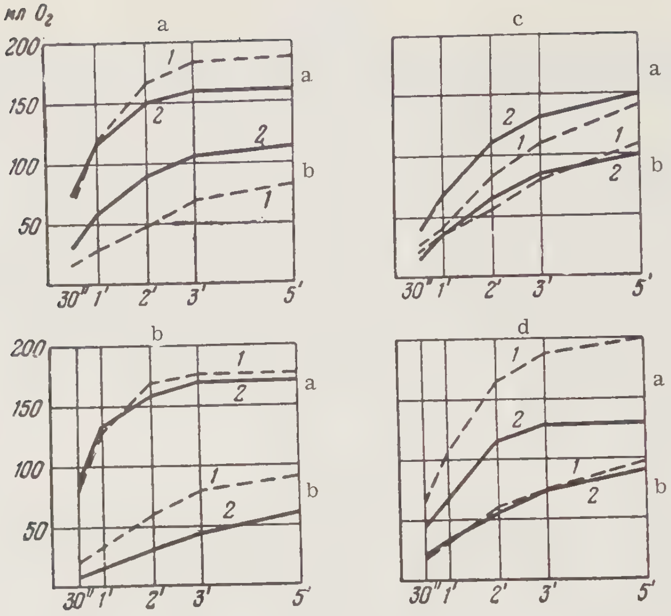

Fig. 1. - Seasonal dynamics in kinetics of catalase activity in dark gray soil under various plantations.

A - oak; B - Norway maple; C - spruce-oak, 1893; spruce remained; D - The same; oak remained. 1 - catalase in ml O_2, May 1956; 2 - catalase activity in ml O_2, September 1956: a - in 5-10 cm layer; b - in 45-55 cm layer.

than in the coniferous (Tables 3 and 4). The litter under European ash and elm shows the lowest invertase activity of all the deciduous litter. In May the invertase activity in the litter proved higher than in September. The litter under ash and 29-year-old oak shows slight seasonal variations in invertase activity.

Invertase activity in elm litter, unlike that in the litter of other trees, proved higher in September than in May. This is most probably due to the autumnal litter fall, which starts earlier with the elm than with other trees.

The dependence of the enzymatic activity of the soil on the composition of the plantation indicates that the main source of free enzymes in forest soil is the root of the tree and grassy vegetation, as a result of exosmosis. The figures for enzyme distribution in the soil profile are therefore some indication of the physiological activity of the root systems of the trees under study in the different soil horizons. The fall in the physiological activity of the root systems in the deeper horizons is apparently due to their respiration conditions. The investigations of Russell and Enpfeldt (21) have shown that the oxygen content in the soil air greatly decreases as the biochemical activity of the soil increases and in particular as the nitrification processes become more intensive. The oxygen regime inevitably deteriorates in the lower layers when there is high biochemical activity in the processes occurring in the forest litter and in the top layers of the soil immediately under the litter This is indirectly confirmed by the values in Table 5, which show a marked decrease in the total biochemical activity in the soil profile, and above all in the nitrification process, which requires good aeration. This process is practically nonexistent at a depth of 50-60 cm under all the trees studied, while the total biochemical activity is 5-7 times less than in the soil layers immediately under the litter.

Under these conditions the normal physiolo cal function of the tree roots in forest soil probably takes place primarily in the top layers. The values for enzyme distribution in the soil profile indirectly bear out this assu tion. These considerations once again raise the question of the importance of roots which penetrate deeply into the soil and subsoil for the processes of biological accumulation of nitrogen and ash elements. The question can be solved only on the basis of direct experimental values, which are at present lacking. Further study of the variations in soil enzym activity in relation to plantings would, in our opinion, make it possible to investigate the specific features of the oxidation-reduction processes and of humus synthesis in the soil.

Conclusions

1. The enzyme activity, nitrification capac

Table 5

Total biochemical activity and nitrification capacity of forest litter and light gray forest-steppe soil under various plantations

Plantation	Period at which sample was taken	Biochemical activity, in mg CO_2 per kg abs. dry mass per hour			Nitrification capacity in mg of NO_3 nitrogen per kg abs. dry mass			
		Depth (cm)			Depth (cm)			
		Forest litter (V) 0—2	3—10	45—60	V 0—2	3—10	20—30	50—60
ak	V	141,0	3,9	0,5	306,7	28,0	4,5	None
	IX	113,8	1,7	0,7	456,4	13,0	4,5	"
aple	V	149,6	3,5	0,6	122,6	26,2	3,9	"
	IX	112,8	2,3	0,8	355,2	17,4	4,0	"
sh	V	173,6	3,8	0,5	619,0	43,3	9,4	"
	IX	117,1	1,6	0,8	135,5	16,5	6,8	"
ime	V	150,8	3,9	0,6	571,5	28,9	4,7	"
	IX	132,1	2,0	0,8	66,9	13,2	5,5	"
lm	V	132,0	3,5	0,6	94,6	27,7	4,0	"
	IX	128,0	1,9	0,6	115,0	12,7	2,2	"
ixed	V	153,2	2,6	0,8	575,7	28,9	4,7	"
	IX	116,0	1,9	0,8	82,5	18,8	3,5	"

ote: Comma represents decimal point.

al biochemical activity ("respiration") of
rest litter, and a dark gray silty clay loam
der late oak, Norway maple, European ash,
all-leaf basswood, elm, and spruce, are
termined (soil conditions apart) by the
ecies composition of the trees forming the
ntation and their rhizosphere.

2. The enzymatic activity of the litter and
l is subject to seasonal dynamics. The dy-
mics in the enzymatic activity of the soil are
st pronounced under a plantation with a
ongly developed fibrous root system (ash,
ple, basswood).

3. The biochemical activity of the soil
creases with depth. Forest litter and the
most layers of the soil (immediately under
litter) are the most biochemically active.
a depth of 50-60 cm the enzymatic activity
the soil appreciably decreases. At this
pth the activity of invertase in the soil under
, maple, elm, and spruce is zero. Nitri-
ation in the soil under these trees gradually
appears in the 30-35 cm layer.

4. The data for enzymatic activity and other
ications of biochemical soil properties indi-
tly indicate the depth at which the most
siologically active root system of the
es is bedded.

5. Investigations into the influence of plan-
on composition on the biochemical and other
perties of soil can be used in working out
ctical measures for regulating the level of
ective fertility of the soil by cultivating
ntations of appropriate composition.

Received July 9, 1959

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HE ROLE OF MINERAL FERTILIZERS IN IRRIGATED AGRICULTURE N BURYAT CHESTNUT SOILS

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The Buryat Autonomous Republic is a Cis-
kalian mountain country. The republic's
riculture is concentrated almost exclusively
the depressions between the mountains —
ng the river valleys and in the gulches.
e bald mountains and mountain slopes are
erally used as sheep pastures.

The least productive plowed soils are the
estnut soils situated in the driest part of
intramontane hollows. Total annual pre-
itation in the chestnut zone is 180-220 mm.
e growing period lasts for 130 days. Aggre-
e temperatures during this period are 2,100-
00°C. The scanty precipitation, the large
nber of clear days, the sharp variations in
nperature, and the frequent strong winds
ravate the dryness of the climate. The
tribution of precipitation is very unfavor-
e throughout the growing period, about 15%
ing in the winter-spring period, 60%-70%
the summer, and 15%-20% in the fall.
e yield of grain crops from the chestnut soils
herefore very low and even after fallowing
ounts to only 3-6 centners per ha. The cul-
tion of forage and vegetation crops which
uire moisture is obviously out of the ques-
n in these soils without irrigation. By
ng its rich water resources, however, the
ntry can convert a part of the chestnut soils
highly productive lands.

The chestnut-soil irrigated area at present
ers only a few hundred hectares, but under
7-Year Plan is to be increased to many
usands of hectares. With the construction
hydroelectric station on the Selenga River,
gation will become the decisive factor in
sing the Republic's agricultural productivity.

Vork done by the agricultural chemical
sion of the Buryat Joint Expedition (USSR
demy of Sciences) has shown that properly
gated and fertilized chestnut soils become
ly fertile and suitable for agricultural
ps (grain, forage, and even vegetable).

The writer's research and field tests on
effectiveness of fertilizers in chestnut
s were performed in 1956 at the Ulan-
n collective farm in the Khorinskiy rayon.
se experiments, which were carried out in
ordance with a fully worked-out scheme,
e the first, and are still the only experi-
ts to have been made on the Republic's
chestnut soils.

The soil in the experiment plot is a chestnut, gravelly-rubbly coarse clay loam of high water-permeability and low water-retention capacity. A standard irrigation with 300-400 m³ of water was sufficient to wet the entire fine-earth layer (40-50 cm) to field moisture capacity. The soil is comparatively rich in humus (3.1%), and contains an appreciable amount of hydrolyzable nitrogen (9 mg N per 100 g), and exchangeable potassium (11 mg K_2O per 100 g), but is poorer in phosphorus (5 mg P_2O_5 per 100 g).

Triplicate tests were made on a 100 m² plot with each of four crops: spring wheat, millet, corn, and potatoes.

A standard 500-600 m³ irrigation was applied on May 5th. This amount was ample to ensure wetting of a soil layer roughly one meter in depth to field moisture capacity.

The wheat and potatoes were irrigated twice during the growing period, the millet and corn once. The standard irrigation during this period was 300-400 m³, applied by flooding strips 3 m wide in the case of the wheat, and by wetting the furrows with a small, weak stream in the case of the other crops.

Spring wheat. One week after the pre-irrigation the experiment plot was divided into wheat plots. Mineral fertilizers were broadcast before plowing with a horse-drawn plow. As the field was extremely stony, plowing was shallow (to a depth of 12-16 cm). This was one of the main reasons for the inadequate wheat yield in the experiment.

The wheat variety Onokhoyskaya 6 was sown crosswise at a depth of 7-8 cm to a standard density of 2 centners per ha.

The experiment established that irrigation had been highly effective (Table 1). Despite the poor tilling of the soil before sowing, the wheat yield from the control (no fertilizer) plot was 14.8 centners per ha, against 3-5 centners per ha in the same year from similar soils, on the same farm, which had not been irrigated. The effectiveness of the mineral fertilizers was also found to be appreciable.

Table 1

Effectiveness of mineral fertilizers on spring wheat[a]

Treatment	Grain yield, cntr/ha (M± m)	Increment	
		cntr/ha	%
Control (without fertilizer)	14,8±0,6	—	—
Pc^{60}	17,6±0,9	2,8	19
Kx^{60}	17,9±1,3	3,1	21
$Pc^{60}Kx^{60}$	19,5±1,5	4,7	31
$Naa^{4}Pc^{60}Kx^{60}$	19,6±1,5	4,8	32

[a] Fertilizers: Pc — Superphosphate; Kx — Potassium chloride; Naa — Ammonium nitrate.

Note: Comma represents decimal point.

As Table 1 indicates, phosphorous-potassium fertilizer was roughly as effective as complete fertilizer (NPK). Nitrogen fertilizer consequently proved less effective than phosphorous and potassium fertilizer. This is due to the richness of the soil in hydrolyzable nitrogen and to the very intensive nitrification activity that sets in when the soil is irrigated during the summer. Even under plants we found appreciable quantities of nitrates (up to 50-80 kg per ha) of nitrogen nitrate in the 0-20 cm layer throughout the summer.

Potatoes. 22 days after irrigation the test plot was plowed with a tractor to a depth of 18-20 cm. On May 25 (before plowing) fertilizers were applied. Planting (spade) by marker was done on May 27 at a density of 60 x 60 cm. The potato variety used was the Lorkh. The standard planting was 2 metric tons per ha. The tubers were covered with 10-12 cm of soil. Even in the early stages of growth the plants on the fertilized lots put out a great deal of high and excellent leafage. Hilling was done on June 2 and the first irrigation in the growing period was immediately applied; the second irrigation was on August 8 during the flowering phase. A second hilling was performed before this irrigation. The crop was gathered on September 1, 67 days after planting, when prolific tuber formation was still taking place, that is, before the plants had fully matured.

The potato yield from the irrigated non-fertilized plot was 160 centners per ha (Table 2) — a fairly high yield in comparison with the yield of about 40 centners per ha from non-irrigated chestnut soils under optimum conditions. Fertilizing increased the yield by 40-70 centners.

It follows from Table 2 that, as in the experiment with wheat, nitrogen fertilizer was less effective than phosphorus and potassium. The nitrogen requirement of the potatoes was largely satisfied from soil nitrates, because of the intensive nitrification activity occurring in the soil.

Corn. The Kharkhov 23 (Minizot 23) averag maturing variety was used. The standard sowing was 18 kg per ha. Sowing was square-hill (60 x 60 cm), by marker, the seeds being set at a depth of 8-9 cm. This was done on Ma 30.

Owing to the brief growing period, the corn was in the milk stage when harvested on August 24.

The green bulk yield of corn on non-irrigate chestnut soils is very low, usually 20-30 centners per ha. The 150 centners per ha (Table 3) obtained from irrigated but non-fertilized soil is therefore sufficiently high. The corn was harvested during the period of intensive bulk accumulation; if it had been harvested later or if an early maturing variety had been used, the green mass yield would have been still higher.

The experiment showed that mineral fertilizers were highly effective, the yield being doubled as a result of NPK fertilizer. Manure was less effective than mineral fertilizers. The inference is that where the growing period is short and a rapid, intensive supply of nutrie to the plant is required, mineral fertilizers are considerably more satisfactory than manure.

Millet. The millet variety used was Omsk 9 sown in wide rows (45 cm between the rows) to a standard of 18 kg per ha, the seeds being placed at a depth of 5-6 cm. Eight days before sowing the area was divided into plots and fertilizer was applied before plowing. Throughout the growing period the plot was clear of weeds and the soil was loose.

The experiment proved very interesting (Table 4). The grain yield obtained with irrigation but without fertilizing was 20.4 centners per ha. The normal millet yield on chestnut soils without irrigation is 2-4 centners per ha; rarely, in good years, it amounts to 6-8 centners per ha. The experiment showe that fertilizing is highly effective, especially when a combination of half the standard amount of mineral fertilizer and manure respectively

Table 2

Effectiveness of mineral fertilizers on potato yields

Treatment	Tuber yield, cntr/ha	Increment	
		cntr/ha	%
Control (without fertilizer)	160±8	—	—
Pc^{90}	214±12	54	34
Kx^{120}	193±14	38	24
$Pc^{90}Kx^{120}$	217±13	57	36
$Naa^{90}Pc^{90}Kx^{120}$	232±12	72	45

Note: Comma represents decimal point.

Table 3

Effectiveness of mineral fertilizers and manure on corn yields

Treatment	Green bulk yield, cntr/ha (M± m)	Increment	
		cntr/ha	%
ontrol (without fertilizer	150±12	—	—
anure20 met t/ha	221±16	71	47
laa^{60}Pc^{60}Kx^{60}	301±21	151	100

ote: Comma represents decimal point.

Table 4

Effectiveness of mineral fertilizers and manure on millet yields

Treatment	Grain yield cntr/ha	Increment	
		cntr/ha	%
Control (without fertilizer)	20,4±1,2	—	—
NPK	27,4±1,5	7,0	34
Manure20 t/ha + +Naa ^{0}Pc^{30}Kx^{45}	32,7±2,1	12,3	60

Note: Comma represents decimal point.

used.

Conclusions

1. Even shallow, gravelly-rubbly varieties chestnut soils can be converted into highly oductive land, suitable for growing a variety agricultural crops, if they are irrigated and tilized.

2. It was established that mineral fertilizers highly effective, provided the soils are igated. The most effective method (shown in the experiment with millet) is to combine manure and mineral fertilizers in half of the standard amounts.

3. Owing to the high content in hydrolysable nitrogen and the intensive nitrification activity in the irrigated chestnut soils, phosphorous-potassium fertilizers are only slightly less effective than complete mineral fertilizer (NPK). Phosphorous-potassium fertilizer can therefore be recommended for wide application in irrigated agriculture.

Received July 5, 1959

METHODS

WATER-PHYSICAL PROPERTIES OF CHESTNUT AND BROWN SOILS IN CERTAIN DISTRICTS OF THE MONGOLIAN PEOPLE'S REPUBLIC

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No data has yet been published on the water-physical properties of soils in the Mongolian People's Republic. With the present extension of irrigation systems in Mongolia, however, these soil properties have become a subject for urgent study, for it is particularly in regard to their water-physical indices that these soils show distinctive peculiarities.

This paper presents the main results of research on the water-physical properties of chestnut and brown soils conducted in 1958 in connection with the planning of a number of irrigation projects.

Chestnut Soils

Chestnut soils in the Kerulen valley were studied. The soils of this district (rayon) are typical of the greater part of Eastern Mongolia. The Kerulen River is the main source of irrigational melioration.

The areas investigated lie within the boundaries of the first and second terraced bottom lands, where the relief is more or less gently sloping. The parent material consists of deluvial and aeolian sandy loams over old alluvial, mainly sandy-gravelly deposits. The land here is virgin soil and the vegetation consists mainly of feathergrass, bistort and Aneurlepidum with Caragana admixtures. The sod formed does not cover the surface continuously. About 20%-30% of the area has remained clear of plants. A certain amount of dead plant residues (twigs) usually accumulates among the plant stalks and undergrowth.

The thickness of the humified (A + B) layer of the chestnut soils varies between 35 and 45 cm. The A horizon contains 1.5%-2.5% of humus, the amount being somewhat smaller in the upper part, in places, than in the lower, owing to the highly skeletal character of the soil (Table 1, Profile 137). The humus content in the B horizon does not exceed 1.5%, falling to 0.15%-0.3% in the underlying parent material. The humified layer is usually somewhat extended in the local depressions with the result that the humus content here will sometimes amount to nearly 1%, even at a depth of 70-80 cm (Table 1, Profiles 71, 11).

Effervescence with hydrochloric acid is not observed within limits of the soil layer. Violen effervescence occurs at a depth of 35-45 cm and below. Below this depth the carbonate CO_2 content reaches 8%-12%. The soils are not saline. The water-soluble salt content in the top 2-meter layer does not exceed 0.1%-0.15% (Table 1).

As Table 2 shows, fine sand particles predominate (up to 50%-65%) in the soil layer proper (to a depth of 35-50 cm). Medium-grained and coarse sand (0.25-1 mm diameter) make up 15%-30% of the layer and skeletal particles are usually present in amounts not exceeding 5%-10% of the total. These characteristics, combined with the soil's low content of colloidal clay particles and organic matter, make for very low water stability of th soil aggregates and impart a number of peculia water-physical properties to these soils.

Small solonetz spots are occasionally found among the chestnut soils, particularly in enclosed local depressions. These seem to owe their development to lacustrine conditions which once prevailed here. The solonetz A horizon is usually sandy loam with a structure similar to that of the chestnut soils. The B horizon is gray-cinnamon brown, of dull lustre, clay loam or clay, and of nutty or blocky-prismatic structure. The faces of the units are sharp and in the dry state do not adhere to one another. The salt content in the A horizon and part of the B horizon does not exceed 0.2%. Within the second half-meter th solonetzes contain 0.8%-1.1% of salts (Table 1) In the solonetz horizon the presence of normal salt can be detected alongside a high total alkalinity (in the sample taken from a depth of 30-40 cm from Profile 23 the $CO_3^=$ is 0.01%). The total area of solonetz spots found in the chestnut soil complexes is negligible. As will be shown below the solonetzes differ sharply from the chestnut soils in their water-physica properties.

The following paragraphs give the characte istics of those water-physical properties of th chestnut soils described above which are usua determined in connection with soil melioration investigations.

Bulk density of the chestnut soils in their natural state, as determined from a sufficient number of tests, is a comparatively stable

Table 1

Chemical analysis of chestnut soils

Profile No.	Soil	Depth, cm	Humus (Tyurin method)	CO_2 (Golubev method)	Hydrolyzable N (Tyurin-Kononova method)	Available P	Available K	Adsorbed cations meq/100 g		Water extract, in % of absolute dry soil						
			%			mg/100 g		Ca	Mg	Dry residue	Total alkalin. as HCO_3	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	$N^+ + Na^+$ by difference
11	Chestnut sandy loam over clay loams	0—6	2,67	None	8,5	5,4	30,0	6,45	4,30	0,092	—	0,003	—	—	—	—
		20—25	1,96	"	9,1	2,2	10,0	10,75	4,30	0,046	—	0,003	—	—	—	—
		45—50	1,47	"	—	—	—	—	—	0,065	0,036	0,001	0,015	0,003	0,002	0,014
		70—75	—	12,5	—	—	—	—	—	0,114	—	0,003	—	—	—	—
		95—100	—	3,9	—	—	—	—	—	0,080	—	0,004	—	—	—	—
		135—140	—	—	—	—	—	—	—	0,078	—	0,003	—	—	—	—
137	Chestnut sandy loam on gravelly-pebbly deposits	0—6	1,54	None	11,2	2,2	15,0	—	—	0,056	—	0,004	—	—	—	—
		20—25	1,52	"	8,6	2,6	3,0	—	—	0,044	—	0,001	—	—	—	—
		50—55	—	8,4	—	—	—	—	—	0,132	0,095	0,077	0,012	0,010	0,003	0,028
		70—90	—	0,04	—	—	—	—	—	0,088	—	—	—	—	—	—
		145—150	—	2,2	—	—	—	—	—	0,054	—	0,006	—	—	—	—
		190—200	—	—	—	—	—	—	—	0,020	—	0,004	—	—	—	—
23	Sandy loam solonetz on clay loam	0—10	1,68	—	—	—	—	—	—	0,012	0,019	0,003	None	—	—	—
		30—40	1,35	—	—	—	—	—	—	0,200	0,110	0,088	0,041	—	—	—
		50—60	—	0,99	—	—	—	—	—	0,850	0,024	0,224	0,624	—	—	—
		80—90	—	—	—	—	—	—	—	1,135	0,036	0,620	0,494	—	—	—
71	Chestnut coarse sandy loam	0—8	1,78	0,33	12,0	2,1	24,0	2,0	1,2	0,100	—	0,006	—	—	—	—
		20—25	1,25	0,35	11,2	0,6	—	—	—	0,013	—	0,007	—	—	—	—
		40—45	1,17	—	—	—	—	3,2	1,6	0,014	—	0,007	—	—	—	—
		70—75	0,81	0,34	—	—	—	—	—	0,185	0,120	0,006	0,071	0,022	None	0,060
		95—100	0,21	0,52	—	—	—	—	—	0,058	—	0,005	—	—	—	—
		150—155	—	0,90	—	—	—	—	—	0,043	—	0,006	—	—	—	—
		190—200	—	0,34	—	—	—	—	—	0,124	0,072	0,008	0,027	0,005	0,001	0,039

Note: All forms of the analyses for Profiles 11 and 137, together with the N, P, K, and adsorbed cations were performed by the Giprovodkhoz (Water economy) laboratory of the USSR Ministry of Agriculture. The other analyses were performed by the Laboratory of the Ministry of Geology of the Mongol People's Republic (Ulan Bator).

Note: Comma represents decimal point.

Table 2

Particle-size analysis of chestnut soils (in %)

Profile No.	Depth, cm	Diameter of particles, mm					
		>1	1,0—0,25	0,25—0,05	0,05—0,01	0,01—0,005	<0,005
11	0—6	—	16,8	62,8	11,8	1,0	7,6
	45—50	—	25,3	50,9	2,0	7,1	14,7
	95—100	39,3	23,2	19,8	1,9	4,3	11,5
137	0—6	—	17,4	65,5	5,8	5,1	6,2
	50—55	45,2	11,5	25,8	1,4	4,9	11,2
	60—75	61,8	<1 мм		38,2	Scattered in field	
	75—90	45,2	»	»	54,8	"	
	145—150	40,2	21,4	27,7	4,1	0,5	6,1
23	0—10	10,0	15,1	64,9	2,0	8,0	—
	50—60	7,2	15,3	62,3	7,6	1,6	6,0
	80—90	20,0	8,3	26,6	22,5	7,2	15,4
	110—120	4,0	4,1	4,5	43,7	39,7	4,0
71	0—6	3,6	25,1	56,4	7,4	3,3	4,2
	20—25	4,3	25,3	65,0	2,5	0,5	2,4
	40—45	9,4	15,0	49,0	13,6	10,8	2,2

Note: The analyses for Profiles 11 and 137 were performed by the Giprovodkhoz laboratory, USSR Ministry of Agriculture; those for Profiles 23 and 71 by the central laboratory of the Ministry of Geology of the Mongolian People's Republic.

Note: Comma represents decimal point.

index. The mean bulk density of the top meter layer varies only between 1.47 and 1.60. The highest bulk density is found in profiles with a sandy-pebbly subsoil (Table 3, Profile 137). The soils with a clay loam subsoil, including solonetzes, have the lowest mean bulk density (Table 3, Profiles 11, 23). Bulk density also varies along the profile, mainly with texture. Sandy-pebbly and sandy-gravelly layers have a bulk density of 1.70-1.80, fine-grained sand and sandy loams 1.50-1.60, and clay loam interlayers 1.40-1.50. The solonetz B horizon is distinguished by being relatively highly compacted (Table 3, Profile 23). The top layer of the soil (0-5, 0-10 cm) is the least compact; bulk density in this layer does not usually exceed 1.40, owing to the loosening action of plant roots and inclusions of plant residues. Profiles where there are considerable quantities of gravelly inclusions constitute an exception; here the bulk density rises to 1.50 (Table 3, Profile 137).

Particle density varies within the considerable range of 2.60-2.80. This is apparently due to the varying amounts of organic residues and heavy minerals. As a rule the particle density of the A horizon, which is richest in organic matter, does not exceed 2.60-2.63; in the B horizon the particle density reaches 2.66-2.67, and in the underlying parent material the usual value is 2.65-2.70. The highest value (2.80) is found in the clay interlays underlying solonetz (Table 3, Profile 23).

Porosity in the top meter layer averages 40%-45%. Mean porosity value is highest in the solonetz (45.5%; Table 3, Profile 23). In the A horizon porosity reaches 50%, falling to 39%-41% in the B horizon. The lowest porosity value occurs in sandy-gravelly deposits, where it is 32%-36%. It should be notec that in clay loam interlays the porosity is appreciably higher than in the sandy or sandy-gravelly layers.

Natural moisture: under natural conditions the moisture contents in the chestnut soil are small, owing to the dry climate and comparativ ly low moisture capacity of the soils. During the summer of 1958 (July-August) the mean moisture content in the top meter layer was 5%-8% or 750-1,040 m³ per ha. Only in the solonetz did it reach 10.5% (1,550 m³ per ha). Apart from the wilting moisture content (roughly 500-800 m³ per ha), available moisture is only 300-500 m³ per ha in all. The solonetzes possess the smallest available moisture conten — less than the wilting moisture content during the observation period. Intensive drying out was also observed in Profile 11 (Table 3). Down the soil profile the layer which suffers the most intensive drying is the A horizon.

Field moisture capacity (minimum field moisture capacity, Rode method), determined on a small area, was found to average 8%-11% (1,200-1,700 m³ per ha) in the top meter layer of the chestnut soils studied.

Table 3

Water-physical properties of chestnut soils

Profile No.	Depth, cm	Bulk density	Particle density	Porosity (%)	Natural moisture		Field moisture capacity		Maximum hygroscopicity (%)	Wilting moisture content (m³/ha)
					%	m³/ha	%	m³/ha		
11	0—10	1,31	2,62	50,0	2,3	30	13,5	175	3,6	70
	10—20		—	—	3,7	50	9,7	125	—	70
	20—40	1,48	2,67	44,5	4,5	135	10,0	300	3,7	160
	40—60	1,48	2,66	44,4	5,5	160	13,5	400	4,4	200
	60—80	1,49	2,66	44,0	7,4	220	10,7	320	4,4	195
	80—100	1,65	2,66	38,0	5,2	170	9,1	300	3,7	180
	0—100	1,48	2,65	44,2	5,1	750	11,0	1630	4,0	870
137	0—10	1,51	2,63	42,6	2,2	35	10,7	160	2,4	55
	10—20	—	—	—	4,6	70	9,5	145	—	55
	20—40	1,50	2,66	43,6	6,4	190	9,3	280	2,6	115
	40—60	1,47	2,65	44,5	11,4	340	8,3	250	5,7	255
	60—80	1,70	—	36,3	4,7	160	5,3	180	0,8	40
	80—100	1,82	2,66	31,6	3,0	110	6,0	220	—	45
	0—100	1,60	2,65	39,7	5,8	930	7,8	1250	2,5	580
23	0—10	1,37	2,60	47,2	3,1	40	14,0	190	1,0	20
	10—20	1,50	—	42,3	4,5	70	12,3	190	—	20
	20—40	1,59	2,61	39,0	8,5	270	12,6	400	7,0	310
	40—60	1,46	2,70	46,0	14,1	410	17,9	520	8,5	410
	60—80	—	2,80	—	10,8	290	17,1	460	9,0	400
	80—100	1,53	2,80	45,5	15,2	470	—	—	10,0	460
	0—100	1,47	2,70	45,5	10,5	1550	15,2	2260	7,1	1600
71	0—10	1,35	2,63	48,6	5,2	70	10,8	150	1,6	30
	10—20	1,43	2,60	45,0	6,0	85	7,9	120	1,0	20
	20—40	1,54	2,60	40,7	6,2	190	7,4	230	1,0	45
	40—60	1,58	2,60	39,2	8,3	260	10,1	300	—	100
	60—80	1,58	—	39,2	—	225	10,0	310	3,3	155
	80—100	1,68	2,60	35,3	—	200	11,1	370	3,2	160
	0—100	1,55	2,60	40,3	6,7	1040	9,6	1490	2,2	510

Note: Particle density and maximum hygroscopicity in Profiles 11 and 137 were determined at
e Glavvodkhoz (Main Water Economy) laboratory of the USSR Ministry of Agriculture; for
rofile 23 and 71 at the Central laboratory of the Ministry of Geology of the Mongolian People's
epublic.

ote: Comma represents decimal point.

This is roughly half the value of, for ex-
le, the field moisture capacity of the clay
n chestnut soil in the northern Caucasus.
erms of field moisture capacity in the top
er layer, the soils can be divided into
e groups: first, chestnut soils primarily
a sandy and sandy-pebbly subsoil, 1,250-
0 m³ per ha (Table 3), Profiles 137, 71);
ond, chestnut soils with sandy — clay loam subsoil — 1,630 m³ per ha (Profile 11); third, solonetzic spots – 2,260 m³ per ha (Profile 23).

Field moisture capacity along the soil profile also depends mainly on the texture of the genetic horizons and intermediate layers. The highest value (17%-18%) occurs in the clay loam layers. In mixed sand and clay loam or sandy loam layers, field moisture capacity decreases to 10%-13%, and in sandy and sandy-gravelly layers it does not exceed 6%-7%. Where the texture of the soil layer is comparatively uniform relatively high moisture capacity is sometimes found in the upper part of the A horizon, apparently as a result of the presence of large quantities of organic residue.

With the moisture content equal to the field moisture capacity the related moisture of the soils is 28%-32% in the case of the chestnut soils with sandy-gravelly subsoil (Profile 137), 37%-42% in the case of chestnut soils with sandy — clay loam subsoil (Profiles 71, 11), and 50% in the case of the solonetz spots (Profile 23).

Maximum hygroscopicity. The witting moisture content was calculated on the basis of one and one-half times maximum hygroscopicity. Depending on the texture, the maximum hygroscopicity value (Mitscherlich method) varied between 0.8% and 10%.

The highest hygroscopicity value (9%-10%)

Table 4

Permeability coefficient of chestnut soils and underlying subsoils (6-8 hour tests)

Profile No.	Depth of pit, m	Texture of soils and underlying subsoils	Permeability coefficient (m/day)	Method	Remarks
137	At surface	Chestnut sandy loam	4,0	Nesterov	
	0,25	"	3,2	"	
	0,9	Gravelly-pebbly mixture	10,0	Laboratory	
11	At surface	Chestnut sandy loam	5,0	Nesterov	
	0,25—0,3	"	1,7—2,6	"	
	0,5	Marly clay loam	1,1	Boldyrev	
42	2,2	Coarse grained sand with gravel	37	Boldyrev	
	»	"	23	Laboratory	
46	8,0	"	18	"	
54	1,5	Gravelly clay loam mixture	0,2	"	48 hour test
92	1,8	Medium and coarse grained sand	19	Laboratory	
	"	"	12	Excavation	Ground partially frozen
23	At surface	Sandy loam solonetz on clay loam subsoil	3,7	Nesterov	Permeability coefficient in excavation material calculated by Forheimer's formula
	0,3—0,4		0,2	"	
57	At surface	Chestnut sandy loam on sandy clay loam subsoil	2,5		
	0,3		1,2		
71	At surface	Chestnut coarse clay loam	5,3	"	
	0,3	"	2,5	"	

Note: Comma represents decimal point.

s found in the solonetz clay loams (Table 3, ofile 23). Maximum hygroscopicity was -7% in the case of sandy — clay loam tex- res, 2%-4% in fine-grained sands and sandy ams, and 0.8%-1.5% in sandy-gravelly layers.

Rate of irrigation for these soils will there- re be comparatively low, owing to their nall moisture capacity. If the available mois- re of the soil is 70% of field moisture capacity, e irrigation rate calculated for a one-meter yer will be 350-500 m^3 per ha; where drying- t to wilting moisture content has occurred, e rate will be 700-1100 m^3 per ha.

The water permeability of the chestnut soils d underlying subsoils is given by the field and boratory test values. The water permeability s found to vary mainly as a function of tex- re. Under field conditions it was found that ter permeability could be affected to some ex- it by the presence of various macropores ch as moles' burrows and so forth, which e rarely encountered down the profile.

In the A horizon the permeability coefficient usually 4-5 meters per day (Table 4). Only certain profiles, where the clay loamy inter- vers approach the surface, does the per- eability coefficient fall to 2.5 meters per y (Table 4, Profile 57). The comparatively gh water permeability of the top soil horizon) is due to its looseness. In the B horizon, ually as a result of its high compactness, the ter permeability is less. In this horizon e permeability coefficient averages 1.5-2.5 eters per day. Deviations from the mean ue are due mainly to variations in texture. ere appreciable amounts of sandy-pebbly rticles are present, the permeability coef- ient rises to 3.2 meters per day (Profile 7); where clay loams predominate it decreases 1.2 meters per day. Water permeability is rticularly low in the B horizon of the solon- es where the permeability coefficient amounts only 0.2 meters per day (Profile 23).

The range of water permeability variation even greater in the underlying subsoils. The rmeability coefficient for gravelly-pebbly and ndy-pebbly deposits is 20-40 meters per day, -20 meters per day for medium grained and arse grained sands, and 1.3 meters per day fine grained sands. Marly clay loams have ermeability coefficient of about 1 meter per . The lowest permeability coefficient (0.2 per day) is found in gravelly clay loams after lay infiltration.

It is noteworthy that both the field and the oratory determinations gave practically nparable values; usually the laboratory tests ld lower values. Profile 92 is an exception. re the subsoil had not completely thawed out er the winter frost.

The presence of high water permeability ermediate layers and lenses in the under- ng parent material creates good conditions natural and artificial drainage of the irriga- n areas.

Brown Soils

Brown soils cover immense areas in the southern and southwestern parts of Mongolia. We studied soil profiles marked out for irrigation in the Baydarik River delta. The area investigated is in the "lake valley" region between the Khangay mountain region and the Mongol Altai (2).

We distinguished two main types of brown soil; brown coarse clay loams and light brown sandy. The parent material of the brown coarse clay loams is alluvial, primarily gravelly-pebbly deposits, and in part aeolian sands. Deluvial deposits have played a negligible part in forming the topmost layers of the soils. Vegetation is of the desert type. Combinations of Eurotia, Caragana, and spear grass make up most of it. Usually not more than 20%-30% of the soil is grass covered.

The brown soils studied are shallow (A + B = 25-30 cm) and highly skeletal. They are covered with a "crust" 3-8 cm thick consisting of gravelly-pebbly particles and sand which have accumulated on the soil surface as a result of wind erosion.

In this crustal layer the skeleton particles including those of more than 5 mm diameter (20%-30%) account for 30%-50%. The A horizon lies under this layer and is about 10 cm thick, of dark cinnamon-brown greyish color, a laminated-like blocky structure and coarse clay loam with inclusions of gravelly-pebbly particles. The skeleton particles in this layer are at a minimum, not exceeding 20%. Content of physical clay is about 25%.

The B horizon is 15-20 cm thick. It is cinnamon-brown in color but many white spots are encountered. The skeletal nature of the particle sizes abruptly increases. Particles larger than 1 mm in diameter make up 60%-70% and more (Table 5). There is a great deal of gravel and pebbly material. The clay loam, which is present in small quantities, is often only a filler in the interstices between coarse particles. The bedrocks are thick gravelly-pebbly alluvial deposits, sometimes with boulder inclusions.

The crust layer does not effervesce with hydrochloric acid. In the soil layer proper effervescence is violent and the carbonate CO_2 content is 1%-4.5%. The humus content in the crust layer is 0.3%-0.5% (in fine earth), 0.8%-1.3% in the A horizon, and about 0.5% in the B horizon. The appreciable content in available nutrients is noteworthy, but the soils are so shallow and coarse that these amounts must be regarded as ephemeral (Profiles 186, 207a).

The light grey sandy soils have been formed on aeolian sand deposits. They are characterized by very slight development of the genetic horizons which are often hardly distinguishable from alluvial subsoils. There is relatively little soil skeleton and the humified layers are very extensive. The humus content does not exceed 1%, the carbonate CO_2 content is 0.3%-0.5%, and the nutrient contents are appreciably smaller than in the brown soils (Profile 207).

The brown soils studied are not saline, the water extracts containing less than 0.1% of salts. These soils are developed in the form

Table 5

Particle size and selected chemical analysis figures for brown soils

Depth, cm	Content as % of fractions, mm									Water extracts, %		Humus, % (Knopp)	CO_2, % (Golubev)	Total N, % (Kjeldahl)	Available P	Available K
	>5	2–5	1–2	1,0–0,25	0,25–0,05	0,05–0,01	0,01–0,005	0,005–0,001	< 0,001	Dry residue	Chloride				mg/100 g	
Light brown sandy soil. Profile 207.																
0—5	9,7	12,8	4,0	4,2	54,6	2,0	1,0	1,2	0,5	0,020	0,001	0,34	—	0,077	—	20,0
15—20	5,8	8,8	3,4	Less than 1 mm 82,0%						0,028	0,002	0,52	0,29	0,038	8,0	20,0
35—40	8,5	8,5	3,8	8,8	61,8	3,1	2,5	2,1	0,9	0,068	0,003	0,28	0,44	0,013	12,0	20,0
65—70	8,5	6,7	3,0	Less than 1 mm 81,8%						0,020	0,002	0,92	0,52	—	—	—
100—105	16,6	8,0	3,2	16,4	49,3	3,2	0,5	2,3	0,5	0,024	0,002	0,67	0,51	—	—	—
Brown coarse clay loam. Profile 207a.																
0—5	18,5	10,4	3,0	Less than 1 mm 68,1%			—	—	—	—	—	0,49	0,67	—	—	—
5—10	10,7	12,9	11,2	Less than 1 mm 65,2%			—	—	—	—	—	0,59	2,91	—	—	—
15—20		1 мм 19,2%		27,9	24,5	2,2	2,6	10,0	13,6	—	—	1,34	1,12	—	—	—
45—50	30,3	24,0	6,5	14,5	20,2	0,8	0,5	1,5	1,7	—	—	—	3,09	—	—	—
Brown coarse clay loam. Profile 186.																
0—3	33,8	15,5	3,2	7,6	36,0	2,4	1,5	—	—	0,018	0,001	0,77	Сл.	0,101	26,0	20,0
4—9	7,8	6,5	3,8	4,3	41,2	9,0	3,2	12,2	12,0	0,054	0,001	0,86	3,00	0,124	12,0	20,0
3—20	25,5	27,0	11,5	6,2	13,2	1,0	2,3	8,2	5,1	—	—	—	4,51	0,109	—	—
30—50	61,0	14,0	8,7	3,2	10,0	0,7	0,4	1,6	0,4	0,030	0,002	0,54	1,62	—	—	—
50—80	51,6	20,0	6,4	11,0	6,9	1,6	0,5	1,4	0,6	0,036	0,003	—	1,98	—	—	—

Note: Analyses by Gidrovodkhoz laboratory, USSR Min. Ag.

Note: Comma represents decimal point.

a complex, brown coarse clay loams gen- ally predominating.

Tables 6 and 7 show the indices for the ter-physical properties of the brown soils. in the case of the chestnut soils these in- ces depend mainly on the lithology and struc- re of the soils in question.

Bulk density of the brown coarse clay loams the soil layer proper varies between 1.36 d 1.67. The lowest value occurs in horizon (1.36-1.47). In horizon B and in the crust er the bulk density is roughly the same at 0-1.67. In the sandy-pebbly layers it is rticularly high, almost 2.00. In the light own sandy soils it is practically uniform oughout the profile examined (1.62-1.67) able 6, Profile 207).

Particle density varies within narrow limits (2.70-2.76). This seems to indicate a fairly homogeneous mineralogical composition of the parent material.

Porosity varies to correspond with bulk density. It is greatest in the A horizon (46%-50%), decreasing to 40% in the crust layer and the B horizon, and to 27%-31% in the parent material. The porosity of the light brown sandy soils, like the bulk density, is practically uniform throughout the profile at roughly 40% (Table 6).

Natural moisture contents during the investigation period (October 1958) were negligible. In the top half-meter of the brown coarse clay loams, they amounted to only 150-230 m³ per ha (1.8%-2.7%). This was equal to or less than the wilting moisture content. Moisture in the sandy light brown soils was also low. In the top half-meter the moisture content was 215 m³

Table 6

Water-physical properties of brown soils

Profile No.	Depth, cm	Bulk density	Particle density	Natural moisture		Field moisture capacity		Maximum hygroscopicity (%)	Wilting moisture content
				%	m³/ha	%	m³/ha		
Light brown sandy soil. Profile 207									
0—10	1,67	2,75	39,3	1,3	20	4,6	80	0,9	25
10—20	1,62	2,76	41,3	2,4	40	5,2	90	1,1	25
20—40	1,63	2,74	40,5	2,8	100	5,6	180	1,2	60
40—60	1,63	2,73	40,3	3,3	110	5,7	180	1,1	50
60—80	1,64	2,73	40,0	2,8	90	5,6	180	1,1	60
80—100	1,64	2,72	39,6	1,9	60	5,5	180	1,0	50
100—150	—	—	—	1,5	130	—	—	—	—
0—100	1,64	2,73	40,0	2,5	410	5,5	900	1,1	260
Brown coarse clay loam. Profile 207a									
0—10	1,59	2,76	42,3	1,7	20	9,6	150	2,6	45
10—20	1,36	2,75	50,4	2,0	30	10,3	140	5,0	80
20—40	1,67	—	38,8	1,8	60	6,7	220	—	100
40—60	1,97	2,70	27,0	2,1	80	4,2	160	1,9	25
0—50	1,65	2,73	39,5	1,8	150	7,0	580	3,3	250
Profile 186									
0—10	1,67	2,74	39,0	2,2	35	10,1	170	3,3	60
10—20	1,47	2,75	46,5	5,9	90	12,6	190	4,7	70
20—40	1,64	2,73	39,8	2,3	70	5,0	160	2,9	85
40—60	1,87	2,71	31,0	1,9	70	3,1	120	2,3	25
60—80	1,94	2,71	28,3	—	—	—	—	—	—
0—50	1,66	2,73	39,2	2,7	230	7,1	590	3,2	230

Note: 1. Maximum hygroscopicity and particle density were determined at the Giprovodkhoz Soil Chemistry Laboratory, Min. Ag. USSR. The wilting moisture content was 1.5 of maximum hygroscopicity.
Note: Comma represents decimal point.

Table 7

Permeability coefficient of brown soils and underlying subsoils (5-8 hour tests)

Profile No.	Depth of pit, m	Texture of soils and underlying subsoils	Permeability coefficient (m/day)	Method
207	At surface	Light brown sandy soil	4,5	Boldyrev
	"	Same	1,5	Laboratory
	0,25	"	5,1	Boldyrev
	0,5	"	3,5	"
			3,2	Laboratory
207a	At surface	Brown corase clay loam	2,4	Boldyrev
	0, 5	Gravelly sand	6,1	"
187	At surface	Brown coarse clay loam	1,7	Nesterov
	0,2	"	1,5	"
	1,0	Sand with pebbles and clay loam admixture	4,3	Boldyrev
257	1,6	Gravel with pebbles and sand	24,0	"
261	1,2	Same	23,0	Laboratory
	1,2	"	37,0	Excavation

Note: Comma represents decimal point.

per ha (2.5%), but owing to the lower hygroscopicity there was a slight amount of available moisture (about 80 m³ per ha) here. This had an effect on the vegetation too. In the light brown sandy soil, despite the general poor vegetation cover, the shrub was distributed more densely and was taller.

Maximum hygroscopicity, shown in Table 6, refers to the fine earth (particles smaller than 1 mm diameter). The appropriate correction was made in calculating the wilting moisture content, the skeletal part of the soil having scarcely any hygroscopic moisture. Maximum hygroscopicity of the brown coarse clay loams varies between 2% and 5% but is uniform throughout the profile at roughly 1% in the light brown sandy soils.

Field moisture capacity of the brown soils is considerably less than that of the chestnut soils. In the half-meter layer of the brown coarse clay loams it is about 600 m³ per ha (7%); in the light brown sandy soils, 450 m³ per ha (5.5%). As can be seen from these values, irrigation rates on these soils will be very small (300-400 m³ per ha) even when the soils are dried to wilting moisture content. As they are highly aerated soils they will quickly dry out and will need frequent irrigations.

The water permeability of the brown coarse clay loams, despite their comparatively highly skeletal particles, is appreciably less than in the light brown sandy soils. This seems to be due to the finer textured fine earth, the properties of which will have a decisive influence on the water permeability of these soils. The permeability coefficient averages 4.5 meters per day in the A horizon of the light brown sandy soils and about 2 meters per day in the brown coarse clay loams; in the B horizon it decreases to 1.5 meters per day. The permeability coefficient varies over a wide range in the underlying layers, depending on the texture of the filling. In the sandy gravell interlays with an admixture of clay loam, and in the fine-grained sands, the permeability coefficient is 4-5 meters per day, and in the gravelly sands about 6 meters per day. Gravelly-pebbly deposits which are comparatively "clean" from clay loam have a permeability coefficient higher than 20 meters per day (Table 7). The permeability coefficient of material excavated from Profile No. 261 was 37 meters per day.

Conclusions

1. The chestnut and brown soils of Mongolia have a structureless coarse texture and are often highly skeletal. They are poor in humus and nutrients. The virgin soils sometimes contain appreciable amounts of available nutrients, but these will be rapidly exhausted once the land is farmed, particularl where irrigation is practiced, and therefore regular application of fertilizers, primarily organic, will be needed.

2. The water-physical properties of these soils are mainly due to their texture. Strongl aerated soils with high water permeability pr dominate; soils with slight water permeability occupy only a negligible area of the chestnut and brown soils studied. The presence of highly water-permeable sandy-pebbly layers make for good natural drainage and may lead

heavy losses from the irrigation network in aces.

3. The water retention capacity of the chest-
it and brown soils is low. This makes it diffi-
ılt for moisture to accumulate in the soil under
y farming conditions; with irrigation, the
ites of water application will need to be small
it frequent.

Received December 7, 1959

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PECULIAR FEATURES OF THE ORGANIC MATTER IN MOLDAVIAN CHERNOZEMS

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"It is scarcely possible to find a more interesting area from the soil standpoint, and that of natural history in general, than the Bessarabian district" wrote Dokuchayev 60 years ago (4). Fourteen years later, Pankov (8) suggested that the greyish tinge of all the Bessarabian chernozems was the result of the climatic peculiarity in the southwest. In recent years, Dimo (3) has pointed out the highly peculiar character of the Moldavian chernozems, which gives basis for distinguishing a Moldavian province, "of geographically wider extent than the republic itself." Ivanova and Rozov (5) suggest that a western (Cis-Black Sea) facies of the chernozem zone should be distinguished, and they divide this zone into three provinces: 1) western Ciscaucasian; 2) central Ciscaucasian, and 3) Danubian. The last named province would include the southern part of Moldavia.

Without going into the question of the boundaries attributed by various authors to the Moldavian chernozems or of the suggested names for the province, we note that all authors emphasize the peculiarity of these soils.

By studying the humus composition of various soil groups a number of investigators (11, 6, 7, 1, 9 and others) have been able to find a pattern in its variation, connected with the genesis of the soils and their geography.

In this paper we shall give the results obtained from investigating the humus content of the following chernozem subgroups, which are the commonest in Moldavia:

1. Deep-effervescing chernozem (name proposed by Dimo for chernozems in which the carbonates have been leached out of the humus horizons but in which no migration of the colloidal fraction can be detected within the soil layer);

2. Typical chernozem;

3. Ordinary chernozem;

4. Carbonate chernozem; and

5. Compact chernozem.

All these soils are fine textured (fine clay loam and coarse clay), the physical clay content in them varying between 56% and 63%. The compact chernozem is an exception, having a medium clay content and containing 77% of physica clay. All these chernozems are thick, the humus horizons being about 85-90 cm thick. The effervescence depth varies (Table 1).

Table 2 gives the values for humus and nitrogen content in the Moldavian chernozems

Humus accumulation in these Moldavian chernozems is peculiar. In the top horizon th humus content is 4%-5%. This should put the soils into the low-humus class, but the very gradual decrease in the humus content with depth causes the total humus content in the to meter layer to be fairly high, not less than in the chernozems of the neighboring Ukrainian province. In the ordinary chernozem, the humus content in the top meter approximates that in the chernozems of central Russia and the Ciscaucasian province. This would seem be due to the moderate arid characteristic of Moldavia at the beginning of the growing peri As the soil gradually dries out, the root systems in their struggle for moisture succeed i penetrating to a considerable depth before the beginning of the dry period. The substantial amount of moisture in the soil during the spri makes for humus formation in a soil layer of considerable thickness, and the dry summer makes for its fixation.

The carbonate chernozems have a lower humus content than the rest. The Bel'tskiy steppe carbonate chernozem, however, is ric er in humus than the carbonate chernozem of the southern Budzhakskiy steppe. The compa chernozems give the highest indices for humu contents. This explains their deep black colo tinged with deep blue. The carbon:nitrogen ratio in the Moldavian chernozems, as in othe chernozems, is fairly wide, widening from th deep effervescing to the carbonate subgroup.

The humus composition was investigated a cording to Tyurin's method (12). Table 3 sho the results. The following peculiarities are typical of the humus composition in Moldavia chernozems: a quite small (1%-3%) content i organic substances which can be extracted wi an alcohol-benzol mixture; no discernible distribution pattern for these substances; a smal amount of humic substances passing into solution on decalcification indicating stability of t humus in these soils. In the carbonate chern zems only a slightly higher content in this pr file can be noticed.

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Table 1

Characteristics selected for comparison of soils

Chernozem	Position in relief	Land use	Thickness of humic horizons	Effervescence depth	Humus content in 0-25 cm layer	Humus content in 0-100 cm layer
			cm		Metric tons /ha	
Deep effervescent, Tyrnovskiy rayon	Plateau	Sown to corn	87	91	120	390
Typical, Bel'tskiy rayon	Plateau	Vetch-oats mixture	110	70	160	540
Ordinary, Kagul'skiy rayon	Plateau	Sown to wheat	94	40	120	420
Carbonate, Bel'tskiy rayon	Crest-shaped watershed	Sown to beet	82	At surface	140	380
Carbonate, Kauchanskiy rayon	Gentle western exposure slope	Fallow	85	"	110	315
Compact, Chimishliyskiy rayon	Gentle slope	Sown to corn	89	23	160	550

Table 2

Humus and nitrogen content in Moldavian chernozems

Chernozem	Depth, cm	Percentage absolute dry soil			C : N
		Humus	C in humus	N	
Deep-effervescing	0—27 27—47 47—57	4,07 3,55 2,03	2,36 2,06 1,18	0,22 0,19 0,11	10,7 10,8 10,7
Typical	0—10 25—35 50—60	5,02 4,22 2,78	2,92 2,45 1,62	0,26 0,22 0,15	11,3 11,1 10,8
Ordinary	0—10 30—40 53—63	4,12 3,91 3,40	2,39 2,27 1,97	0,20 0,19 0,18	11,9 11,9 10,9
Carbonate, North	0—10 25—35 35—45	4,65 4,02 3,00	2,74 2,33 1,74	0,23 0,20 0,16	11,9 11,6 10,9
arbonate, South	0—13 15—25 32—42	3,97 3,61 2,95	2,30 2,15 1,72	0,19 0,18 0,15	12,1 11,9 11,4
ompact	0—10 30—40	5,00 3,96	2,90 2,30	0,28 0,12	10,3 11,5

ote: Comma represents decimal point.

Table 3

Humus content in Moldavian SSR chernozems in % of total organic carbon in original soil

Chernozem	Depth, cm	Organic original soil C as % of weight of dried soil	Alcohol-benzol extract C	C extracted on decalcification of soil	Humic acid C			Fulvic acid C			Residual C	Grand total	Humic acid C / Fulvic acid C	Humic acid C / Residual C	Mobile humic acid C
					Fractions I	Fractions II	Total	Fractions I	Fractions II	Total					
Deep effervescing	0—27 27—47 47—57	2,36 2,06 1,18	2,1 2,4 1,7	3,4 2,9 1,7	35,6 34,5 32,2	9,7 5,3 6,7	45,3 39,8 38,9	18,6 18,0 16,1	2,9 2,9 2,5	21,5 20,9 18,5	27,7 31,1 35,7	100,0 97,1 96,6	2,1 1,9 2,1	1,6 1,3 1,1	5,1 4,4 4,3
Typical	0—10 25—35 50—60	2,92 2,45 1,62	0,68 2,0 1,2	2,7 2,9 2,4	36,0 33,1 33,3	9,3 8,9 6,1	45,3 42,0 39,4	22,3 17,9 17,9	2,4 2,4 1,8	24,7 20,0 19,7	25,7 28,9 35,8	99,1 95,8 93,5	1,8 2,1 2,0	1,8 1,5 1,1	4,1 2,4 2,1
Ordinary	0—10 30—40 53—63	2,39 2,27 1,97	3,4 2,2 2,0	3,3 1,3 1,5	33,1 32,1 29,9	7,5 6,2 6,3	40,6 38,3 36,2	16,7 16,8 15,2	3,3 2,6 2,5	20,0 19,4 17,7	31,3 35,9 38,9	98,6 97,1 96,3	2,1 2,0 2,0	1,3 1,1 0,9	3,5 3,1 2,0
Carbonate, North	0—10 25—35 35—45	2,74 2,33 1,74	2,6 1,7 2,3	3,7 7,3 4,6	29,2 26,2 28,1	10,6 10,3 9,0	39,8 36,5 37,1	15,7 15,0 17,2	2,2 3,4 3,4	17,9 18,4 20,6	34,4 33,1 35,2	98,4 97,0 99,8	2,2 1,7 1,8	1,2 1,1 1,0	1,8 1,7 1,1
Carbonate, South	0—13 15—25 32—42	2,30 2,15 1,72	2,2 3,3 2,9	3,0 5,1 2,9	30,0 32,1 28,7	8,7 10,2 8,2	38,7 42,3 36,9	14,8 14,9 15,9	3,0 2,3 2,9	17,8 17,2 18,7	33,9 30,7 35,9	95,6 98,6 97,3	2,1 2,4 1,9	1,1 1,4 1,1	3,3 3,7 2,3
Compact	0—10 30—40	2,90 2,30	0,73 2,9	3,1 3,0	36,9 43,0	6,2 5,7	43,1 48,7	14,5 11,7	2,6 2,2	17,1 13,9	34,9 28,7	98,9 97,2	2,5 3,5	1,2 1,7	2,8 1,7

Note: Comma represents decimal point.

Humic substances extractable with a 0.1 n lution of NaOH after decalcification of the soil action I) are represented by humic acids and vic acids loosely bound to the mineral part of soil. In the typical, compact and deep-ervescing chernozems fraction I makes up re than 50% of the total humus; the highest rcentage, 58%, is in the typical chernozem. e ordinary and carbonate chernozems have a ghtly lower content in their fraction (about %). In all the soil studied the content in this ction diminishes with depth.

The major part of fraction I consists of humic ds, which are the most complex of the humic bstances. Their formation and accumulation typical of the humus formation process in ernozems. The humic acid content is twice as h as the fulvic acid content, and in the com- t chernozem even 2.5-3.7 times higher; in the e of the carbonate chernozem 70%-80% of the al humic acid amount passes over into alkaline ract, 80%-85% in the case of the typical, dinary and deep-effervescing subgroups and %-90% in the case of the compact subgroup.

Humic and fulvic acids more firmly bound to mineral part of the soil (extractable by alter- e treatment with 0.1 n solutions of acid and ali) make up roughly one-tenth of the humus t (fraction II). The content in this fraction, as he case of fraction I, diminishes with depth. vider humic-fulvic acid ratio (2.3-4.8) is ical of this fraction.

The content in insoluble humic residues mins) firmly bound to the mineral part of the makes up about one-third of the total humus tent and increases with depth. The top hori- s of the ordinary and carbonate chernozems e the highest amount of insoluble residue (in nparison with the other subgroups).

The content in free humic acid or humic acids nd with available forms of R_2O_3, extractable neans of a single direct treatment of the ori- l soil with 0.1 n NaOH, is slight in the davian chernozems (2%-5%), and diminishes reciably with depth. The largest quantity of e acids is found in the deep effervescing sub- up, the smallest quantity in the carbonate and pact subgroups.

Iumic acids markedly predominate over fulvic s in the humus composition of the Moldavian rnozems, the ratio varying around 2. The ic acid amount is largest in the typical cher- em, lower in the deep-effervescing, and very h lower in the ordinary and carbonate sub- ps. Humic acid accumulation, followed by in accumulation, is most pronounced in the cal chernozems of the Bel'tskiy steppe, which ain more of these substances than the cor- onding soils of central Russia, whereas the c acid content is appreciably lower than in e soils. The humic—fulvic acid ratio does vary within the soil profile, but the humic to humin ratio narrows, owing to the rela- y high humin content.

he deep-effervescing chernozem represents ntermediate stage between the typical and the ned. Its characteristic feature is increased ability of humic acids combined with re- d total humic acid content as compared with ypical chernozems. In the ordinary chernozem the humin share in the humus composition increases as the accumulation of humic and fulvic acids decreases, with the result that the humic acid to humin ratio approaches unity.

The Moldavian ordinary chernozem differs from the central Russian chernozems in the same way as the typical subgroup.

In the carbonate chernozems we note the same tendency towards more moderate accumulation of humic acids and also of humins. It is interesting to find that in regard to the content in the various fractions and the ratio between them these soils are similar to the Ciscaucasian carbonate chernozems.

According to Rudenskaya's values (10) the humic acid, fulvic acid, and humin contents in the Ciscaucasian chernozems are similar to that in the Moldavian chernozems, particularly the carbonate subgroup, in which—as in the case of the Ciscaucasian soils—the fulvic acid content is found to increase with depth. These soils are also similar in the general character of humus accumulation in the soil profile.

The compact chernozems occupy a special place. There is no basis for classifying them as solonetzic soils, since in addition to the absence of adsorbed sodium they differ from these in the nature of their humus, where humic acids and humins predominate, while the fulvic acids, even by comparison with other chernozems, play a small part. It would seem that conditions for surface meadow formation periodically occur during the wet season owing to the fine texture. This is borne out by the appreciable amount of ferrous oxide in the top horizons and its diminution with depth. These conditions make for humus accumulation, and the compact chernozems are in fact the richest in humus.

The Moldavian chernozems, then, have common features which confirm the humus formation pattern established for chernozems by Tyurin (11). In addition, however, they have certain peculiarities which are expressed in a deep and uniform humification of the soil profile despite the low humus content in the top horizon, and in the sizable total humus content. This is reflected as a more intensive accumulation of humic acids and humins in the humus composition, and a less intensive accumulation of fulvic acids, owing to the formation in the soils of favorable conditions for the formation of highly complex and highly condensed humic substances. These considerations should provide the explanation, in particular, for the good granular structure of the Moldavian chernozems despite their notably low humus content in the top humus-accumulative horizons, as compared with the chernozems of the Central Russian province. The typical chernozems have the best structure and it is in these that the humus-formation features we have mentioned are most pronounced.

All these signs make the Moldavian chernozems similar to those of Ciscaucasia.

Received March 5, 1960

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RACTICAL APPLICATION OF ONESHTY STATE FARM GRICULTURAL SOIL RESEARCH IN CONNECTION ITH THE USE OF FERTILIZERS

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The seven-year plan calls for a steep rise in ldavian agricultural production, and for the nversion of that country into a land of flourishing crops. The attainment of these targets will be very largely conditional upon improving the fertility of Moldavia's soils, and on

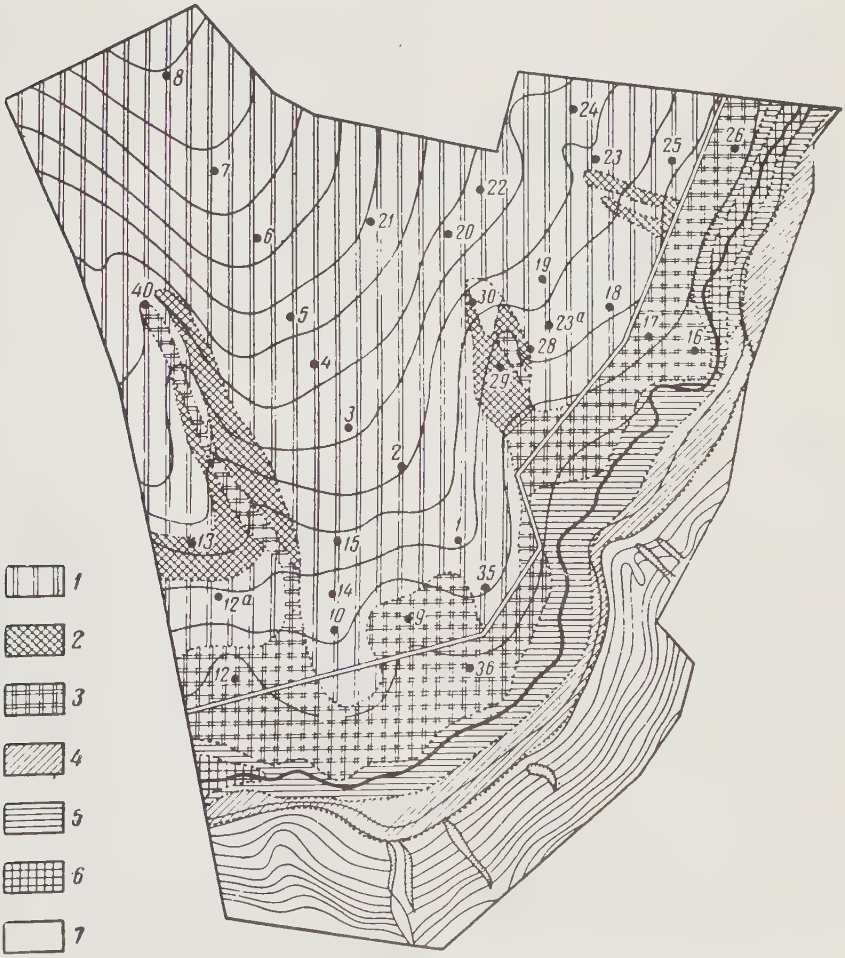

Fig. 1. - Soil map of the Oneshty State Farm, Karpinenskiy district, Moldavian SSR.

1 - Ordinary chernozems, thick, fine clay loam. 2 - Ordinary chernozems, shallow, slightly, and moderately eroded, carbonate clay loam. 3 - Thick valley medium clay loam chernozems. 4 - Alluvial carbonate medium clay loam chernozems. 5 - Bottom land-meadow structured clay loams and fine clay loams. 6 - Meadow-bog solonchak fine clay loams. 7 - Strongly eroded carbonate clay loams.

Table 1

Explanation of Oneshty State Farm's soil map

Soil	Relief	Soil-forming parent material	Estimated agricultural usefulness of soils and recommendations	Group Number	Area hectar
Ordinary chernozems, thick heavily loam.	Watershed plateau and gentle slopes	Loess-like clay loam	Best quality on farm; suitable for all field crops and vineyards.	I	814.
Ordinary chernozems, shallow, slightly, and moderately eroded, carbonate clay loams.	Gentle ravine slopes	"	Medium as regards natural qualities, suitable for field crops and vineyards. Owing to the relief condition of the soil, soil conservation, and improvement in the phosphate and nitrogen regime are required.	II	80.
Thick valley chernozems, medium clay loam.	Bottom land terrace	"	Best in regard to agronomic soil properties, suitable under all agricultural crops, best for orchard and vegetable crops.	I	267.
Alluvial chernozems, carbonate, medium clay loam.	Foothill slopes	Deluvial clay loam	Good as regards soil qualities, suitable for corn, grass and vegetable crops, requires improvement in phosphate regime.	II	114.
Bottom land-meadow, structured clay loam and fine clay loam.	High parts of bottom land	Alluvial clay loam	Good highly fertile soils, suitable under vegetable crops, and root crops.	III	40.
Meadow-bog solonchak, fine clay loam.	Low parts of bottom land		Poorest soils, permanently excessively wet, unsuitable for agricultural crops, main use — natural hay and pasture.	IV	25.
Strongly eroded carbonate, clay loam.	Steep slopes	Loess-like clay loam	Unsuitable for plowing, promising for grasses and afforestation.	V	280.

proper and intelligent use of these soils by the country's collective and state farms.

To make proper and intelligent use of soils as the main productive force in agriculture, a good knowledge of their natural agronomic and productive properties is needed. In this connection the practical use of agricultural soil maps and charts becomes highly important. Large-scale maps and charts showing the detailed characteristics of the useful soil groups are being used by the agronomists, land managers, economists, melioration experts, and directors of collective and state farms in working out and applying the appropriate combination of methods for higher-yield campaigns, and in creating conditions for running agriculture on an improved scientific basis.

At the same time, provided soil scientists actively help in getting the productive practice of collective and state farms well and truly imbued with the ideas represented in these maps and charts, the latter can become the best form

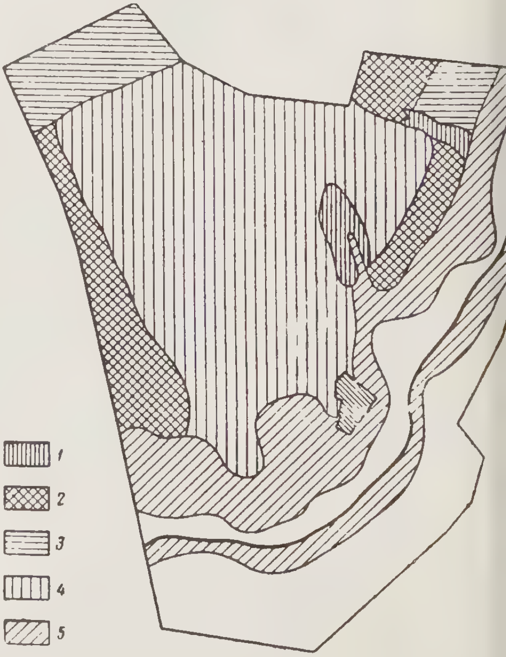

Fig. 2 - Phosphorous and potassium availability in Oneshty soils.

1 - Very poor; 2 - P poor, K medium; 3 - P poor, K good; 4 - P and K medium; 5 - P medium, K good.

Table 2

Chemical characteristics of Oneshty State Farm soils

Soil	Profile No.	Depth, cm	Humus (%), (Tyurin method)	Salt pH	Total adsorbed cations, meq/100 g of soil	Available nutrients, mg per 100 g of soil		
						Hydrolyz. nitrogen (Tyurin-Kononova method)	P_2O_5 (by Truog)	K_2O (by Peyve-Mil'ne)
Ordinary chernozem thick, clay loam	1	0—10	2,63	6,2	24,2	9,4	18,1	20,0
		30—40	2,84	6,2	30,6	7,6	8,0	17,0
		55—65	—	0,4	30,6	5,7	6,8	12,0
The same	2	0—10	3,02	6,4	—	6,9	11,9	16,2
		30—40	2,57	6,4	29,3	7,8	8,5	12,1
Ordinary chernozem thick, fine clay loam	3	0—10	3,87	6,4	33,3	7,5	17,5	14,5
		30—40	3,42	6,4	33,3	5,4	18,3	12,4
The same	4	0—10	3,19	6,8	33,1	7,6	5,7	18,7
		25—35	3,21	—	35,2	8,2	4,2	13,4
		46—56	2,73	6,8	36,1	4,5	10,7	16,6
The same	5	0—10	4,18	6,0	38,4	10,3	18,6	12,1
		30—40	3,34	6,0	36,9	6,2	3,0	17,9
		60—70	2,59	6,6	34,1	0,8	21,6	14,5
The same	6	0—10	4,12	6,6	41,1	7,8	29,5	11,7
		35—45	3,87	6,8	37,8	6,0	5,9	14,1
		52—62	2,30	6,8	35,7	7,5	3,5	10,0
The same	7	0—10	3,93	6,8	38,4	9,1	15,3	15,1
		30—40	3,31	7,2	—	2,7	15,4	12,4
Ordinary chernozem, medium thick, fine clay loam	8	0—10	4,20	6,8	37,6	5,4	6,6	23,6
		30—40	2,82	6,8	32,0	1,4	2,9	13,1
		50—60	2,51	7,4	34,7	—	6,4	7,3
Ordinary chernozem passing to a thick clay loam	10	0—10	2,94	6,4	28,9	0,9	15,7	18,8
		30—40	2,82	6,4	35,4	9,4	8,8	10,7
		46—56	1,78	7,4	—	9,7	6,6	9,7
The same	15	0—10	—	6,4	—	5,7	8,7	17,5
		25—35		6,4	33,1	8,4	6,5	15,8
Ordinary chernozem, fine clay loam	18	0—10	—	6,8	29,9	8,6	7,8	11,1
		30—40	—	7,0	41,1	5,7	3,9	8,3
		50—60	—	7,0	—	—	—	—
		140—150	—	7,4	—	—	—	—
The same	22	0—10	—	6,0	31,6	5,7	5,6	13,1
		30—40	—	7,0	26,5	6,9	12,0	8,1
		46—56	—	7,0	32,0	7,4	2,5	7,3
The same	25	0—10	—	6,2	27,4	6,9	2,0	24,6
		35—45	—	6,2	33,5	10,9	11,2	7,7

Note: Comma represents decimal point.

hich scientific knowledge about local soils be popularized among agronomists and the ning community as a whole.

Despite the indisputable economic value of agricultural soil maps little has yet been done to work out how they can be put to practical use.

Table 3

Phosphorous and potassium content in soils and requirement in fertilizer

Soil contour number on map	Phosphorus		Potassium	
	Content, mg per 100 g	Requirement in fertilizer	Content, mg per 100 g	Req. in fertilizer
1	1—2	Very high	12—18	Medium
2	6—10	High	12—18	Medium
3	6—10	Medium	20—25	Low
4	10—18	Medium	12—18	Medium
5	13—18	Medium	20—25	Low

The topic is given extremely minor importance in agricultural soil science.

Many years of experience in compiling large-scale agricultural soil maps and introducing these into collective and state farms has led us to conclude that a more practical economic use of large scale agricultural soil mapping is essential. This paper describes an experiment in the effective practical use of the results of agricultural soil research done in accordance with a more than usually comprehensive program, in which field experiments with fertilizers applied by a state farm agronomist were taken into account.

Land utilization and natural conditions on the Oneshty State Farm. The Oneshty farming land covers a total area of 1,620 ha situated between the Prut and Lapushna Rivers in the southern chernozem zone of Moldavia. Until 1956 the Oneshty was a grain farm. Like other grain farms it has now been handed over to the Sovnarkhoz (Council of National Economy). In 1956, orchards and vineyards were planted and the land utilization pattern of the farm altered: up to 500 ha are now allotted to vineyards, 156 ha to orchards; after the orchard and vineyard planting program has been completed, 329 ha will be given over to field crops, 215 ha to pasture, 61 ha to woodlots, and 50 ha will be used as a windbreak.

The greater part of the land use is a watershed, sloping slightly to the southeast. A sma part forms the steep north-northwest slope of watershed.

The main elements in the mesorelief are watersheds, slopes, bottom land, and bottom land terraces, although the last named are not very pronounced. The relief of the northern a northwestern or left bank part of the farm land level or slightly undulating. This is the area suitable for plowing. The southern and southwestern or right bank part is unsuitable for plowing and is being used for grasses and afforestation.

Soils and their agronomic characteristics. Oneshty soils belong to a family of soil types (1, Table 1) comprising four agriculturally productive groups requiring identical or similar methods of cultivation for their improvement a proper utilization.

The first group includes the best soils on th farm. Given the proper advanced agricultural practices, these soils produce high yields in grain, oil, fruit and vineyard crops. The grou consists of: 1. Ordinary chernozems, primar thick; 2. Thick (valley) terrace chernozems which, as can be seen from the map, are the principal and commonest soils on the farm. These have a very thick humus-accumulative

Table 4

Yield compared with soil characteristics

Soil	Content in available substances, mg per 100 g of soil			Degree of cultivation	Winter wheat yield, cntr/ha	
	Hydrolyzable nitrogen	P_2O_5	K_2O		1954	1955
Ordinary chernozems, mainly thick, fine clay loam	5,5—7,5	6,5—18	12—18	Medium	20	25
Thick terrace valley chernozems, fine clay loam	7,5—12	13—18	20—25	Good	30	40

Note: Comma represents decimal point.

Table 5

Effectiveness of organo-mineral fertilizers on young vineyards

Treatment	Yield, cntr/ha			
	White shasla (desert grape)	Yield increment, %	Italian rice 1958	Yield increment, %
Control	22	—	17	—
7 centners crushed superphosphate + 3.5 centners ammonium nitrate + 1.5 centners K_2O[a]	35	59	25	47

[a] Fertilizer was added by means of a VUMT-60 machine in two layers (65-70 and 35-40 cm respectively).

Table 6

Effectiveness of organo-mineral mixture on old vineyards with hybrid varieties more than 30 years old

Treatment	Yield, cntr/ha		Yield increment, %	1958 yield	Yield increment, %
	1956	1957			
Without fertilizer	26	28	—	30	—
14 metric tons manure + 7 centners superphosphate applied as top dressing and later turned in	—	58	100,7	67	120,3

Note: Comma represents decimal point.

zon, 80-120 cm deep. In texture they are of
ine and medium clay loams. The humus
ent (Table 2) in the fine clay loam horizons
es between 3.9% and 4.2%; in the medium
loams, between 3.0% and 3.2%. In terms of
enerally accepted chernozem classification,
e soils should be regarded as low-humus,
n terms of the total humus quantity in their
le they are fairly humus-rich and are not
ior to medium-humus chernozems.

ne reaction of the soils in the first group
es from slightly acid to neutral—a good
acteristic from the point of view of agricul-
crop growth and microbiological processes.
adsorption capacity of the chernozems
ribed varies between 30 and 41 meq per 100
soil. These soils have the agriculturally
ble feature of a stable blocky-granular
ture, which owes its formation to the high
ation of chernozems with alkaline earth
ns and to the presence of humus and clay
cles in sufficient quantity. This structure
them agriculturally favorable qualities:
have a friable structure, possess good buf-
g capacity, and are biologically highly active.
possess large total and available nitrogen
nt, corresponding to the adequate humus
y.

regard to available forms of phosphorus the chernozems we are describing fall into three groups, depending on whether the P_2O_5 availability is poor, slight, or medium (1-5 mg, 5-10 mg, and 10.5-18 mg P_2O_5 per 100 g of soil, respectively) (Table 3). As Figure 2 shows, the slightly alluvial and slightly eroded carbonate chernozems, and the ordinary chernozems occupying the sectors furthest removed from the farm center are poorest in available forms of phosphorus. The first requirement for these soils is to improve the phosphate regime. The ordinary thick and terrace chernozems with a medium or slight phosphorous supply are also responsive to phosphorous fertilizers. The chernozems are better supplied with available potassium than they are with available phosphorus, and can be divided into "medium" and "adequate" from this point of view (10-15 mg and 16-25 mg K_2O per 100 g of soil, respectively).

Being highly fertile soils, the chernozems of the first agriculturally productive group respond well to the addition of fertilizers. This is confirmed both by the yields (Table 4) and by direct experimental values for the reaction of this group of soils to fertilizers. The classification of soil into poor, weak, medium, and adequate as regards phosphorous and potassium availability, indicated previously, is only a rough guide and will be subject to amendment in the direction of greater precision as further data accumulate; such data are extremely necessary, both in order to improve the picture of the agriculturally productive characteristics of the soils, and for the purpose of compiling agricultural soil maps.

Tables 5 and 6 give data[1] for the effect of mineral fertilizers on soils of the first group in the Oneshty State Farm. The crop consisted of European varieties of vines.

Organic and mineral fertilizers were added in autumn 1956 to a 28-ha vineyard, more than 30 years old, containing hybrid varieties, where the soils were notably deficient in phosphorus. The fertilizer was broadcast and subsequently plowed in. In 1957 and 1958 the yield from individual fertilized plots amounted to 90-110 centners per ha.

The second agriculturally useful group consists of shallow, slightly and moderately eroded, and slightly alluvial carbonate chernozems. Unlike those of the first group these soils are not widely distributed. Their thickness throughout the profile and its humic horizon is slight or medium and they are therefore less fertile. Owing to chemical peculiarities caused by the high carbonate content, phosphorous compounds occur throughout the profile in forms not readily soluble; therefore, in order to enhance the effective fertility of these soils it is necessary to improve their phosphate regime: the eroded soils need conservation methods of tilling, and the deep-placement addition of large quantities of organic fertilizer. The carbonate chernozems are suitable for field crops and vines, but are not promising for orchards.

The third agriculturally productive group consists of occasional meadow, slightly waterlogged, and meadow-bog saline soils developed where the mineralized ground-water level has been near the surface. High and excess wetting fosters the development of meadow and meadow-bog vegetation, which gives medium and low quality hay. These soils are therefore used as low grade meadow pasturelands.

The large organic matter content in these soils create a considerable fertility potential in the and the productivity of this group of soils can increased by means of drainage and drying-ou operations, plowing up, and cultivation. Afte melioration it becomes possible to grow not o high quality grasses and forage crops in these soils but also vegetable crops.

The fourth "agriculturally useful" group co sists of strongly eroded and washed out soils which are unsuitable for plowing and have no productive value. These soils are best used f forestation and grasses, but given the right cu tivation they can also be used under fruit crop and berries.

Conclusions

1. An agronomic assessment of the variou soils, relief, and organizational-economic conditions on the state farm, based on detaile soil study, has made it possible to plan the appropriate allocation of the lands to orchards and vineyards according to their biological peculiarities and environmental requirements.

2. Practical use of the chemical results graphically expressed on charts has revealed differences in the effective fertility of the soil in their present state, and has shown that thes differences are closely connected with yield. Actual yields confirm this.

3. The fact that the soils on this farm var in regard to their chemical regime indicates t a differential approach is required in deciding how best to use fertilizers under the various crops.

4. Chemical research to discover the pres state of the soil's fertility should be combined with field experiments in the use of fertilizers This is bound up with the necessity for more thorough knowledge of the agronomic characte istics of the soils, and for basing fertilizer utilization on scientifically and economically sound principles.

Received November 11, 1959

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[1] Data provided by L. S. Gulyayev, agronomist-viticulturalist.

MMONIFICATION AND NITRIFICATION IN THE SOILS
F CERTAIN TYPES OF CUTOVER AREAS
ARKHANGEL'SK OBLAST'

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t Chemistry, USSR Academy of Sciences

The study of ammonification and nitrification soil has great importance in connection with il fertility characteristics. In the case of for- t soils in particular it is of interest to find w the rate of these processes varies after cover. This question has received relatively tle attention in the literature and seems to ve been scarcely studied at all in connection h the northern region of the European part of USSR.

Mention has been made in published papers 6, 9, 10) of the stimulating effect of felling on rate of ammonification and nitrification ocesses. Information on the ammonification d nitrification capacity of soils in cutover eas can also be found in Pobedinskiy, Orfanit- y, Smirnov, Rogovoy and Zabello (5, 4, 8 and

We studied the ammonification and nitrifica- n capacity of the organogenic horizon and up- r part of the podzolic layer of a soil in the andozerskiy forest of the Plesetskiy forest ea, Arkhangel'sk Oblast (northern part of the ddle taiga subzone) in 1958. Common hair- ass (Deschampsia flexuosa) and willowweed rnt-cutover area are widespread here (ac- rding to Melekhov, 3). The first form on yria-Vaccinium spruce-forest sites, the cond under the same conditions after burning s occurred in the cutover areas. Table 1 mmarizes the characteristics of the experi- nt plots. All the plots were similar in re- rd to soil conditions and differed from one other mainly in the character of their A_0 rizons. The following is a morphological scription of a typical soil profile in experi- ntal area No. 3.

Profile 110. Shallow humic-iron sandy loam lzol developed on two component boulder al- ium.

A_0 0-5 cm. Forest litter consisting of d mosses and cones, brown and cinnamon- wn color, loose, fresh; lower semi-decayed er penetrated by tree roots.

A_2 5-13 (15) cm. Whitish, cinnamon- wn and grey humified parts encountered in top t of horizon; structureless, rather compacted, sh, sandy loam. Abrupt color transition to t horizon, by tongues; very occasional roots.

B_1 13(15)-19 cm. Cinnamon-brownish and ochrous, structureless, rather compacted, damp, bound sand with small boulders. Second spruce root concentration peak found here. Transition to next horizon gradual.

B_2 19-35 cm. Brownish-yellow in top part, greyish-brown lower down. Sandy loam with small boulders. Transition to next horizon gradual.

B_3g 35-43 cm. Grey-brown with dark bluish tint, moist. Gritty sandy loam with gravel.

C_1 43-65 cm. Variable in color and texture; reddish brown sections of compact clay loam alternate with dark bluish-gray sandy loams and sands. Some boulders.

C_2 65-107 cm. Red-brown, nutty, moist boulder clay loam.

Table 4 shows some of the chemical property characteristics of the experimental soils.

Ammonia and nitrates were determined in fresh and composted mixed samples. The individual samples were taken on 10 occasions between June 5-8, July 20-23, and September 18-20, The ammonia was determined with Nessler's reagent, and the nitrate colorimetrically with disulfophenol acid. Aluminum sulfate and potassium hydroxide were used to decolorize the extracts. The samples were composted at a temperature of 20-25°C and at optimum soil moisture content for 15 days.

The weather during the summer of 1958 was approximately the same as the average for a number of years. The mean mensual air temperature in July was +18.4°C, against a long-time average of +19.4°C; the corresponding figures for August were +16.5°C, and +16.4°C, respectively. Mean monthly precipitation in July was 60 mm against a long-time average of 67 mm: corresponding values for August were 79 and 74 mm, respectively.

Temperature and soil moisture were observed on some of the experiment plots. It was found that the soil temperature at a depth of 5 cm (top part of the mineral layer) averaged 1°C lower than at a depth of 2 cm (in the A_0 horizon). Throughout the observation period the soil temperature of the hairgrass cutover area was lower than that of the willowweed-burned areas. Table 2

Table 1

Characteristics of experimental areas

Exp't. area No.	Plot	Age of cutover area, years	Vegetation	Characteristics of A_0 horizon
2	Oxyria-Vaccinium spruce forest, age class IV	—	Composition of stand: 6 spruce, 2 pine, 2 birch, density 1.0; site class IV. Live above-soil cover includes semi-shrubs—bilberry, mountain cranberry, green mosses, oxalis.	4-5 cm thick. Forest litter.
11	Potentially hairgrass cutover area	1	Bilberry, mountain cranberry, majanthemum oxalis, ground pine, green mosses. Occasional hairgrass.	Semidecayed forest litter, 4 cm thick.
3	Hairgrass felling area	4	Hairgrass predominates, covering 45%-50% of area. Bilberry, mountain cranberry, majanthemum, woodrush, Dryopteris felix mas, oxalis, green mosses also occur.	5 cm thick. Semidecay forest litter penetrated hairgrass roots.
1	The same	8	65% of area covered with hairgrass. Sparse spruce undergrowth and mountain ash are covered with mountain cranberry, willowweed, majanthemum, woodrush and others.	4 cm thick. Loose hair grass sod 1-1.5 cm thick on top, semidecay litter penetrated by hai grass roots underneath
10	Recently burnt	—	Sparse willowweed	Forest litter 4-5 cm thick, charred on top (cm).
5	Willowgrass-burnt cutover area	3	Willowweed predominates covering 55% of area; density 42 stalks per m².	2-3 cm thick. Forest litter, charred on top (cm).
"	Fire site (areas on site of burnt stumps, brushwood)	"	No vegetation. Ash layer on surface.	None
7	Willowgrass-burnt cutover area	5	Willowweed covers 33%, density 25 stalks per m². Some raspberry bushes.	2 cm thick. Well decay from burnt residues of forest litter and willow weed and raspberry litt
6	The same	8	Willowweed covers 7%; Politrichum commune, 69.4%; some common hairgrass, woodrush, horsetail, and bilberry.	3 cm thick. Charred, semidecayed forest litt penetrated by rhizoids haircap moss.

shows the soil moisture values.

The data in Table 3 show the ammonification process in the top horizons of the soil. The ammonium nitrogen content was highest in the year-old litter of the potentially hairgrass cutover (area 11). In the same area, the study of the soil microflora (12) revealed more intensive growth of aerobic cellulose-decomposing bacteria, as compared with the forest and other hairgrass cutover area soils.

The ammonium nitrogen amount is lower in the 4-8-year-old hairgrass cutover areas. The ammonification process in the A_0 horizon prob weakens as the hairgrass cutover areas becon older, because of a reduction in quantity and change in composition in the energy-producing material in it. During the summer the ammor um nitrogen content in the A'_0 horizon increase reaching its maximum in the samples collecte in July. It seems that under central taiga con ditions the optimum conditions for ammonifica and decay of the litter exist during the summe months. There is no prolonged intensive dryi of the A_0 horizon here during the summer, as there is in the forest soils of the southern taig and of the coniferous-broadleaf forests, wher

Table 2

Soil moisture of surface horizons in experimental plots, % by weight

Experiment area Number	Type of experimental area	Horizon	Date	
			June 10-11	July 17-19
2	Oxalis bilberry spruce forest, age class IV	A_0'	125,0	203,6
		A_0''	30,5	203,8
		A_2^a	23,9	22,3
11	One-year-old potentially hairgrass cutover area	A_0'	129,6	280,0
		A_0''	78,5	239,6
		A_2	30,1	33,4
10	One-year-old burnt area	A_0'	13,1	182,8
		A_0''	80,0	167,0
		A_2	22,3	25,5
5	Willowgrass-burnt cutover area, 3 years old	A_0	55,0	133,2
		A_2	22,5	23,2
7	Willowgrass-burnt cutover area, 5 years old	A_0	122,0	133,0
		A_2	25,3	24,4
6	Willowgrass-burnt cutover area, 8 years old	A_0	124,8	188,9
		A_2	28,3	35,0

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[a] In all plots the top part of the podzolic horizon was taken.

Note: Comma represents decimal point.

ammonium nitrogen content is found to de- ase during the dry summer months (2,8).

n the A''$_0$ horizon the ammonium nitrogen tent is observed to diminish slightly in July, ept in the case of the year old potentially rgrass cutover area. This is probably due to nitrogen demand of the growing vegetation, e it is precisely in this part of the litter the main mass of live roots is concentrated. ne samples collected in September, hardly difference was observed in the ammonium ogen content in the A'$_0$ and A''$_0$ horizons re was some accumulation of ammonium ogen in the A''$_0$ horizon). In the A$_2$ horizon ammonium nitrogen content was 5-10 times er than in the A$_0$ horizon.

n examining the data for ammonium nitrogen ent in the composted samples it must be d that the highest ammonification capacity oughout all the periods during which the ples were taken) belongs to the forest litter ne-year-old and four-year-old hairgrass ver areas. Composting of the samples col- ed in the fall showed that these had an am- ifying capacity one and one-half to two times higher than that of the composted samples taken in June. The comparatively high ammonifying capacity of these litter samples may possibly be due to enrichment of the A$_0$ horizon in readily decaying material as a result of the litter fall (2). In all sectors of the hairgrass cutover areas the top part of the litter possesses greater ammonifying capacity than the lower.

The ammonium nitrogen content in the fresh and composted samples of the top soil horizons of the willowweed burnt-cutover areas was considerably lower than that of the hairgrass areas. In the fresh samples of this type of cutover area the ammonium nitrogen amount varied on the average between 10 and 100 mg per 100 g of soil (Table 3). When the samples were composted the ammonium nitrogen content increased by 50% to 100%. The ammonifying capacity of the top soil horizons increased with the age of the willowweed burnt-cutover areas, owing to the accumulation of organic matter in the A$_0$ horizon.

The ammonification capacity was higher in July than in June in all the samples from the willowweed burnt-cutover areas. The lowest amount of ammonium nitrogen was found in the

Table 3

Variation in the ammonification capacity of felling-area soils, in mg N NH_3 per kg absolute dry weight of soil

Experimental area No.	Type of experimental area	Horizon	June 5-2		July 20-23		Sept. 18-20	
			Samples					
			Fresh	Composted	Fresh	Composted	Fresh	Composted
2	Spruce forest, age class IV	A_0'	95,5	207,0	131,0	515,0	91,0	451,0
		A_0''	86,0	116,0	75,0	391,0	118,0	201,0
		A_2[a]	14,2	20,0	17,5	41.6	13,7	42,2
11	One-year-old potentially hairgrass cutover area	A_0'	310,0	456,0	392,0	—	265,0	580,0
		A_0''	152,0	221,0	200,0	415,0	261,0	340,0
		A_2	15,7	50,5	38,9	54,1	22,3	126,0
3	Four-year-old hairgrass cutover area	A_0'	104,0	319,0	120,0	—	169,0	539,0
		A_0''	101,0	221,0	86,0	415,0	176,0	320,0
		A_2	19,4	22,5	24,0	27,1	13,8	59,0
1	Eight-year-old hairgrass cutover area	A_0'	90,0	176,0	100,0	410,0	83,6	524,0
		A_0''	75,6	140,0	73,6	344,0	84,0	148,0
		A_2	12,8	47,1	51,1	59,0	11,5	47,6
5	Willowgrass-burnt cutover area, 3 years old	A_0	25,0	44,0	53,0	185,0	36,8	52,0
		A_2	11,0	26,3	24,8	20,7	11,2	25,4
7	Willowgrass-burnt cutover area, 5 years old	A_0	41,3	67,4	74,0	112,0	58,1	88,0
		A_2	14,8	41,6	25,0	33,7	12,8	26,0
6	Willowgrass-burnt cutover area, 8 years old	A_0	75,7	145,5	84,0	173,0	68,0	340,0
		A_2	14,4	21,9	65,0	73,6	14.0	93,0
5	Fire site	Ash	29,2	39,2	53,5	50,9	—	—
		A_2	5,3	10,5	3,1	34,1	—	—

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[a] The top part of the podzolic horizon was taken from all plots.

Note: The values for the content of litter required for converting the ammonium nitrogen content into quantities per ha have been published in papers by Yu. A. Orfanitskiy in the collection: Principles of cutover area classification and its importance in forestry. Arkhangel'sk, 1959.

Note: Comma represents decimal point.

ash layer at the burnt sites, where hardly any difference could be detected between the fresh and the composted samples in regard to ammonification.

Determination of the nitrifying capacity of the soils showed (Table 4) that the soil nitrogen nitrate mobilization process occurs most completely in the three to five-year-old willowweed burnt-cutover areas. The nitrifying capacity of soil here (composted samples) is five to ten times higher than in the case of the hairgrass cutover areas. This indicates that burning followed by occupation of the cutover area by willowherb has a favorable effect on the nitrification process: the soil acidity is reduce the nutrition regime and aeration improve; the temperature of the top horizons is 2-3°C highe than that of forest soils — a very important poi under northern conditions. Our information is corroborated by Tvorogova's microbiological research (12), which showed that in soils of

Table 4

Dynamics of nitrification capacity of soils in cutover areas, mg N NO_3 per kg absolute dry soil

Experimental area Number	Type of experimental area	Horizon	Samples 5–8.VI		Samples 20–23.VII		Samples 18–20.IX		Humus, %	Available forms, mg/100 g of soil		pH in water	Exchang. Ca meq per 100 g of soil	Degree of cation saturation, %	Wax-resins % soil	$\frac{C}{N}$
			Fresh	Composted	Fresh	Composted	Fresh	Composted		P_2O_5 (by Kirsanov)	K_2O (by Peyve)					
2	Spruce forest, age class IV	A_0'	1,7	2,4	2,0	13,7	0,5	6,3	75,3	61,3	90,6	4,9	28,0	81,1	—	—
		A_0''	1,2	2,4	1,5	11,5	1,2	5,4	61,7	33,2	90,8	4,4	11,2	81,4	6,3	22,4
		A_2^a	0,2	0,5	0,4	0,8	0,2	0,9	1,4	2,2	5,0	4,3	1,1	57,4	—	—
11	One-year-old potentially hairgrass cutover area	A_0'	2,6	4,8	2,4	—	1,1	9,2	71,6	40,9	72,4	5,8	15,2	—	—	—
		A_0''	2,4	3,6	2,5	—	1,3	7,1	34,8	21,1	42,2	4,9	15,2	—	—	—
		A_2	0,3	0,4	0,8	1,6	0,1	1,0	0,9	1,4	6,7	4,4	0,9	—	—	—
3	Four-year-old hairgrass cutover area	A_0'	1,8	3,4	3,9	—	1,3	8,3	66,5	50,0	86,4	5,8	32,2	81,1	—	—
		A_0''	2,3	3,6	2,4	20,4	1,4	11,9	46,9	25,3	59,1	5,2	27,7	71,9	5,8	17,4
		A_2	0,6	1,2	0,7	0,8	0,1	0,7	0,7	0,8	5,0	4,5	0,9	67,5	—	—
1	Eight-year-old hairgrass cutover area	A_0'	1,8	5,2	3,1	23,1	0,8	7,6	65,2	40,3	71,5	5,8	22,0	85,4	—	—
		A_0''	1,3	4,0	1,6	19,0	0,8	7,0	47,7	17,9	35,3	4,9	20,0	93,1	3,4	15,4
		A_2	0,6	0,8	0,4	1,1	0,2	1,0	1,4	1,8	6,7	5,9	1,5	67,6	—	—
10	Recently burned	A_0	1,1	33,0	1,6	78,0	0,5	65,2	52,7	106,9	92,0	6,7	18,2	—	—	—
		A_2	0,6	0,80	0,6	0,9	0,1	1,2	0,5	1,6	76,4	5,4	0,8	—	—	—
5	Willowgrass-burnt cutover area, 3 years old	A_0	1,2	120,0	1,4	77,0	0,5	104,5	41,4	193,3	87,6	6,3	48,0	—	2,0	12,6
		A_2	0,4	8,8	0,6	3,1	0,1	4,7	1,2	1,0	—	5,8	2,0	—	—	—
7	Willowgrass-burnt cutover area, 5 years old	A_0	1,5	42,0	1,7	65,0	0,4	35,2	54,9	17,6	88,0	6,1	40,7	—	3,5	11,9
		A_2	0,4	1,0	0,5	0,8	0,1	2,4	1,4	0,8	26,6	5,3	1,4	—	—	—
6	Willowgrass-burnt cutover area, 8 years old	A_0	1,4	1,6	1,6	11,0	0,5	5,1	60,3	15,2	81,0	5,3	32,3	—	3,7	10,5
		A_2	0,4	1,2	0,4	0,6	0,2	0,9	2,5	1,4	40,0	5,0	1,8	—	—	—

[a] The top part of the podzolic horizon was taken from all plots.

Note: See Table 3.

Note: Comma represents decimal point.

willowweed burnt-cutover areas the number of nitrifying bacteria is hundreds of times greater than in forest and hairgrass cutover area soils. Composting of the eight-year-old willowweed burnt area samples only slightly increased the nitrification. In the case under consideration this seems to be due to the properties of the A_0 horizon, which has been largely formed from haircap moss litter and the cones of young pines. The favorable effect of the heavily thinned willowherb, and long past burning, is reduced by new environmental factors unfavorable to nitrification.

In the fresh samples from the willowweed burnt-cutover areas the nitrate nitrogen amount was found to be negligible. This must be because the densely growing willowherb actively absorbs the nitrate nitrogen formed in the soil. In the fresh samples of the forest litter and of the hairgrass cutover areas the nitrate nitrogen amount was also found to be negligible, but increased in the one year and eight-year-old cutover areas.

In the composted samples more nitrates were detected in the soil from the eight-year-old hairgrass cutover area. This corresponds to a high degree of saturation in cations, the narrowest C:N ratio, and a lower bitumen content than is found in the other plots (Table 4).

In examining the seasonal changes in the nitrate content in the soil of both types of cutover area one finds a striking increase in the amount of nitrate nitrogen in the fresh samples collected in July. On composting, the best nitrifying capacity is possessed by samples taken in July, the worst by those taken at the beginning of June. The samples taken in September occupy an intermediate position in regard to nitrate nitrogen content.

Comparison of the ammonium and nitrogen nitrate content in the soils studied with the conditions influencing the intensity of these processes shows that the amount of ammonia and nitrates is very closely connected with the soil pH. Very pronounced ammonification and poor nitrification in semi-decomposed, rather damp, litter is observed when the reaction in these layers is acid: the pH of water suspension is 4.3-5.8. With a pH of 6.1-6.7, as in the case of the willowweed burnt-cutover areas, oxidation of the ammonium compounds into nitrates occurs, but only given optimum soil moisture and composting temperature.

Our data for the ammonium and nitrate nitrogen content in the forest and cutover area soils differ from those of Sukhareva (9) for oxalis-spruce and cutover areas in the Yaroslav Oblast'. We obtained high values for the nitrate nitrogen content in the forest soils, amounting to 200-300 mg per kg of soil in the forest litter and 470 mg per kg of soil in the cutover areas.

Conclusions

1. The one-year-old potentially hairgrass cutover area possessed the highest ammonifying capacity. The ammonifying capacity of the A_0 horizon diminished with the age of the hairgrass cutover areas.

2. The ammonifying capacity of the A_0 hori is found to increase in the willowgrass burnt-c over areas with increase in the age of the cuto area. The nitrifying capacity of the soils in th one- to five-year-old willowgrass burnt-cutove areas is five to ten times higher than that of th hairgrass cutover areas.

3. The clearest indication of differences in ammonification and nitrification in the top laye of the cutover areas is the soil acidity.

4. Data for the nitrifying and ammonifying capacity of the top horizons of the podzolic soi of the northeastern part of the central taiga su zone show that there is fairly considerable biochemical activity in them during the summer.

5. The ammonifying and nitrifying capacity of the soil is a fairly clear index to the differe in fertility of the top soil horizons in cutover areas, depending on their vegetation cover (typ of cutover area) and age. Fresh hairgrass an one to five-year-old willowgrass burnt-cutover areas should be regarded as the best (in regar to nitrogen supply) for regeneration of forest.

Received February 19, 1960

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MECHANICAL STABILITY OF AGGREGATES IN WESTERN CISCAUCASIAN CHERNOZEMS

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The moisture-deficiency regions, where the retention and accumulation of moisture in the soil is a decisive factor in obtaining high yields, the structure and compaction of the soil are of particular importance.

Experimental studies at the Agrophysical Institute (F. Ye. Kolyasev) and researches in the agricultural faculty of the Kuban Agricultural Institute show that when the soil dries out in the summer months a granular structure (aggregates not larger than 10 mm) must be maintained in the plowed layer, which must be evenly compacted and protected by a shallow friable layer.

Intensive cultivation with various implements is often needed to impart this condition to fine-textured soils such as the Kuban chernozems. V. R. Vil'yams repeatedly warned that there was a danger of pulverizing the soil by machine cultivation.

It therefore became necessary to establish the extent to which various implements destroy and pulverize soil aggregates in the Kuban, where the soil has to be intensively cultivated during the 7 month dry period.

Studied of the effect of repeated cultivation on the pulverization of the soil structure were made as early as 1932 in the Krasnodar Tobacco and Makhorka Institute (3). It was concluded from these studies that the Western-Ciscaucasian chernozems were highly resistant to machine cultivation. These studies failed, however, to take account of the influence of various conditions.

Pulverization of the soil by different implements was studied on the college farm of the Kuban Agricultural Institute from 1955 through 1958 when soil cultivation experiments were co ducted with the various crops of a rotation. It was found that there was almost no pulverization when a roller was used on winter crops an only slight pulverization when cultivators and harrows were used.

In 1958 special experiments were set up on fine-textured Western-Ciscaucasian leached chernozem at this farm (67%-70% physical clay in the soil, and 40%-43% clay particles). The fect of repeated cultivation with a cultivator, a disc harrow, a spiketooth harrow, and a roller was determined. Each implement was passed over the field ten times in succession. Shortly after this treatment 6 soil samples of approximately 1 kg were taken from the cultivate layer. A little later a second set of samples w taken.

The samples were subjected to dry fractiona tion in an air dry state. Aggregate stability wa also determined by Savvinov's method. The sa ples were analyzed immediately after they had been taken, in a natural condition.

Table 1

Result of dry and wet fractionation as percentages of soil weight

Treatment of the soil	Diameter of aggregates, mm					Percentage of water stable aggregates
	>10	10—5	5—1	1—0,25	<0.25	
Harrowing 10 times	21,6	19,8	35,8	17,7	4,9	49,89
Packing 10 times	20,1	17,0	34,0	22,0	7,4	46,49
Discing 10 times	21,0	16,2	27,14	25,4	10,2	45,33
Cultivation 10 times	30,16	16,87	22,5	20,1	9,33	47,4
Control, without additional working	18,24	20,53	38,9	17,8	4,45	54,2

Note: Comma represents decimal point.

Table 2

Results of dry and wet fractionation, % of soil weight

Soil treatments	Diameter of aggregates, mm					Percentage of water stable aggregates
	>10	10—5	5—1	1—0,25	< 0,25	
arrowing 10 times	10,3	28,4	25,2	30,8	5,0	52,3
acking 10 times	19,6	24,95	19,4	32,7	4,6	53,7
scing 10 times	18,1	28,7	20,8	27,7	4,5	50,8
ltivation 10 times	15,4	32,0	23,8	23,7	4,6	51,3

Note: Comma represents decimal point.

ie experiment was commenced in 1958 on reas. One area had been maintained as black fallow for 4 years. No perennial ses had ever been sown. Soil moisture was) in the 0-8 cm layer, 19.6% in the 8-10 yer, and 24% in the 10-15 cm layer. The tooth harrow worked to 7-8 cm, the disc w to 8-10 cm, the cultivator to 10 cm, and ompacting effect of the roller was observed lepth of 6-7 cm. Table 1 gives the results lysis of the samples taken after the treat-

ien soil moisture in the cultivated layer was close to maximum hygroscopicity the largest amount of dust was produced by the disc implement and the arrow-shaped cultivator.

Samples were once again taken 27 days later on July 5, 1958 from the same cultivation treatments. During this period there had been 61.2 mm of precipitation, and the 31.5 mm of rain that fell on June 19 had wetted the whole plowed horizon almost to field capacity.

Table 2 shows that the precipitation assisted aggregation (1, 2). The structure was identical on plots that had been repeatedly worked with

Table 3

Water stability, in mm of water, and cohesion of aggregates, in kg of pressure, for different soil moisture contents

mm	Moisture content, %											
	25		30		35		40		45		50	
	Water stability	Cohesion	Water stability	Cohesion	Water stability	Cohesion	Water stability	Cohestion	Water stability	Cohesion	Water stability	Cohesion
)	6,0	0,9	7,0	1,1	23,8	3,0	32,0	7,3	33,6	5,4	13,6	3,3
3	1,0	0,54	4,0	0,94	16,4	2,3	19,4	3,3	17,0	3,5	8,0	1,2

te: Comma represents decimal point.

Table 4

Results of dry and wet fractionation, %

Soil treatment	Diameter of dry aggregates, mm					Percentage of water stable aggregates
	>10	10—3	3—1	1—0,25	< 0,25	
rowing 10 times	18,3	25,7	27,7	27,0	4,2	49,6
king 10 times	42,2	23,0	13,5	16,3	4,4	54,7
ing 10 times	18,25	26,6	24,4	25,9	4,9	52,2
ivation 10 times	25,0	24,2	19,31	26,22	5,2	48,8
rol, without additional rking	24,64	31,5	20,14	18,8	4,6	55,86

e: Comma represents decimal point.

Table 5

Results of dry and wet fractionation of soil samples, %

Soil treatment	Diameter of aggregates, mm						Percentage of water stable aggregates
	>10	10—7	7—3	3—1	1—0,25	<0,25	
Harrowing 10 times	15,28	11,46	21,23	20,3	29,0	2,7	60,8
Packing 10 times	34,93	7,36	23,0	20,13	12,83	1,77	62,36
Cultivation 10 times	23,16	14,4	21,6	17,96	19,4	3,4	58,95
Discing 10 times	18,73	17,93	19,23	17,56	21,83	4,7	60,69
Without additional working	20,71	10,19	22,0	21,48	23,06	2,6	64,1

Note: Comma represents decimal point.

Table 6

Resistance to crushing, kg

Soil	Diameter of aggregates, mm		
	10—7	5—3	3—1
Carbonate chernozem (Kalnibolotskaya, Novo-Pokrovskiy district)	6,4	2,96	0,53
Leached chernozem (Krasnodar)	10,9	4,7	0,63
Compact chernozem (Kellermesskaya, Giaginskiy district)	17,2	5,04	0,76

Note: Comma represents decimal point.

different implements.

A small laboratory experiment was conducted to establish the effect of soil moisture on aggregation. The soil—a leached chernozem—was ground in a morter and the fraction >0.25 mm in diameter was sieved out, samples taken from this fraction were wetted to 25%, 30%, 35%, 40%, 45%, and 50%. The soil was mixed for 5 minutes and then air dried. The water stability of the aggregates was determined after dry fractionation by dropping water on them from a burette. The water stability was expressed in terms of the amount of distilled water required to destroy the aggregates.

The experiment was repeated five times. The cohesiveness of the aggregates in an air dry state was also determined and expressed in kilograms of pressure needed to destroy the aggregates.

It is clear from Table 3 that both water stability and cohesion were highest when the moisture content in the soil was approximately 40%. This moisture clearly creates the best conditions for the packing of the particles on mixing. As it dries out the particles come closer together and the colloids and colloidal films come into contact and form a single system, the mechanical stability of which increases as moisture decreases.

The experiment involving repeated working of black fallow was repeated on June 21, 1958 when the soil was more moist: 17.3% in the 0 3 cm layer, 24.81% between 3 and 8 cm, and 24.4% between 8 and 15 cm. Our observation show that this moisture is close to optimum moisture for surface working, since at this stage the soil is easily granulated and it does not give rise to much dust. This is confirme by the analytical data in Table 4.

The large quantity of water-stable aggrega on plots that had been packed and disced when soil moisture was favorable is clearly due to effect of soil compaction on aggregation.

A second similar experiment was conducte on an alfalfa field plowed and sown to winter wheat. On July 12, 1958 when the experimen was conducted the soil moisture was 7.12% in the 0-3 cm layer, 22.7% between 3 and 5 cm, 24.5% between 5 and 10 cm.

Table 5 shows that when the sod was turne over there was less dust than on bare fallow the same moisture content. Also, there was significant mechanical destruction of the aggregates even when the surface tilling implements were passed over the soil ten times. H ever, although the absolute amount of dust wa less than on the control, subsequent working caused more soil pulverization than on the ba fallows.

The percentage of dust (<0.25 mm) in our

periments did not exceed 10% on bare fallow
d 5% on the turned sod. This amount of dust
not sufficient to worsen the water-physical
operties of the soil.

The high resistance of the aggregates in
ıban chernozems to mechanical destruction is
e to the high content of organic matter in these
ils, and also to surface tension forces in the
inerals of the clay particles. Compact cher-
zem has the highest percentage of clay par-
les (50%-60%), leached chernozem has 40%-
%, and carbonate chernozems 35%-40%. The
ntent of clay particles affects their cohesion
the aggregate, as is shown by the use of
essure to destroy aggregates of various dia-
eters taken from the three chernozems of the
ıban (Table 6). The samples were air dry.

Conclusions

1. The fine-textured chernozems of the
ıban have a high clay content in the absence of
rge and medium sand fractions. They have a
rge active surface area and this allows con-
uous aggregation of the particles. The ag-
egates are more cohesive than in soils of
arser texture.

2. There is little pulverization of the soil
en the leached chernozems of the Kuban are worked at optimum moisture content (22%-26% moisture by weight, 55%-65% of total water capacity). With a lower soil moisture content the quantity of dust doubled.

3. Pulverization is highest on dry soil that is repeatedly worked with a disc implement and a cultivator. Harrowing and rolling cause less pulverization.

Received March 7, 1959

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THE DYNAMICS OF WATER-STABLE SOIL STRUCTURE IN A GRASS-ARABLE ROTATION

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It is generally accepted that the fertility of clay loams and clays is largely dependent on their structure, since structure determines the water, air, and biological regime of the soil and consequently its nutrient regime. It is also known that owing to the features of their genesis, sod-podzolic soils are not easily structured. Work on the features of structure formation in such soils when used for agriculture is therefore of great scientific and practical importance.

We have been studying the dynamics of water-stable structure on sod-moderately podzolized silty clay loam for a number of years. Its potential capacity for aggregation is slight, since the amount of clay and fine silt does not exceed 13.7%, and the humus content is approximately 2%. The study was mainly centered on an experimental rotation in a field of the college farm at the Ivanov Agricultural Institute. The area consisted of seven widely spaced plots with the following crop rotations: 1 — black fallow; 2 — winter crops with undersown grasses; 3 and 4 — grasses; 5 — spring grains; 6 — potatoes; and 7 — oats.

The organic fertilizers used (peat — manure compost) were applied to the fallow (40 metric tons/ha) and to the potatoes (15 metric tons). The fallow was limed (2 metric tons/ha). An additional 5 cntr of agricultural lime were applied in the first year of grasses. The following mineral fertilizers were applied in the course of the rotation: 70 kg N, 165 kg P_2O_5, and 225 kg K_2O phosphorus-potassium fertilizers were used on the fallow after harvesting the cover crop, on second year grasses, on oats sown after grasses, and on potatoes. Nitrogen was applied to the winter wheats (early spring top dressing), to grasses in the first year of utilization, and to potatoes. The cultivation of the soil was fully up to modern standards.

The work of T. S. Mal'tsev has led in recent years to a greatly increased interest in the role of annual crop plants in changing the properties and fertility of the soil. Several works devoted to this question have been published (1, 4, 5, 6, 7, 8, 9 etc). We have been interested in the structure forming role of annual and perennial plants in a field grass-arable rotation. In order to clarify the direct influence of plants that affect the formation and destruction of soil structure, three unsown 4 plots were left in each of the experiment field of the rotation. Soil samples for structural aggregation analysis were taken on these plots and from beneath the plants. Mixed samples taken from the three fixed points in the fields were analyzed. The sample for aggregate analysis was made up according to Savvinov's instructions. Sieving in water was carried out in a Baksheyev apparatus after th aggregates had been saturated by capillarity for 30 minutes.

This work has yielded a great deal of statis tical material. Figure 1 shows the most typical features in the seasonal dynamics of the aggregate composition of the soil beneath the main crops in the rotation.

It is clear from Figure 1 that changes in th water-stability of the soil structure throughou the season vary by crop. Thus the quantity o water-stable aggregates in the soil under oats reaches its maximum at harvest time and the gradually decreases until late autumn. On th manured potato field the structure is slightly dispersed but the quantity of aggregates >1 m in diameter, most valuable from the point of view of agriculture, increases by harvest tim The water-stability of the structure increase gradually throughout the whole growing perio beneath perennial grasses in the second year, and especially beneath winter crops undersow with grasses on manured and limed fallows.

When changes in the soil moisture are compared with the dynamics of the water-stable aggregates content, one finds that soil moistu is a fundamental factor in seasonal variations in the water-stability of the structure. An increase in moisture is normally accompanied a decrease in the quantity of water-stable agg gates and the converse also holds. This dependency is most clearly marked in aggregat >1 mm in diameter. The quantity of smaller aggregates is less dependent on the moisture state of the soil. This feature does not hold in the autumn for land under grasses, and fo manured winter crops undersown with grass mixture — the quantity of water-stable aggregates in the plowed layer is also perceptibly creased when soil moisture increases.

A similar feature is found when one compares the curves for structural dynamics an

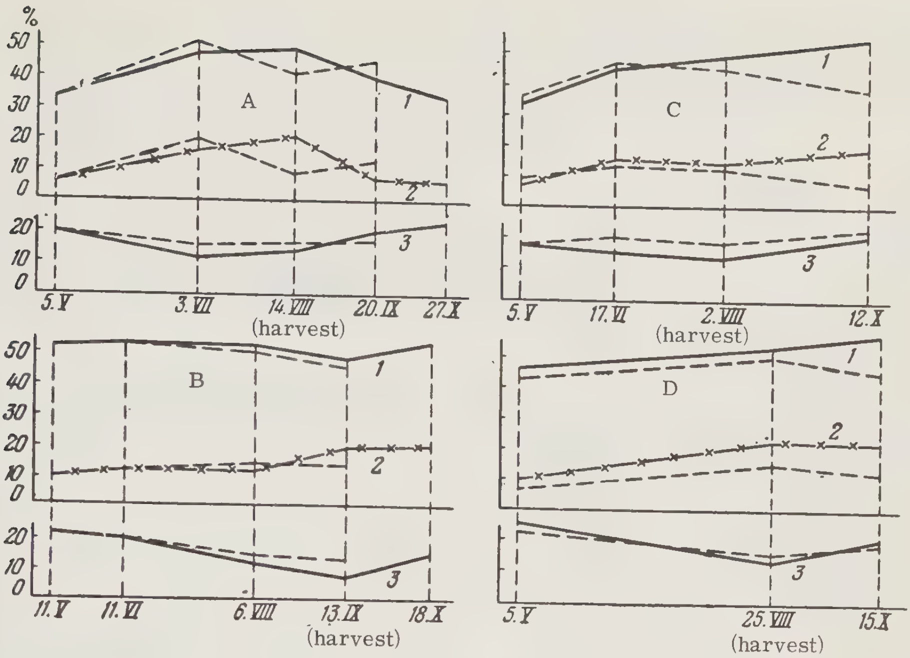

Fig. 1. - Features of the seasonal dynamics of the water-stable structure of the soil under the various crops in a rotation.

A - Oats, 1956; B - potatoes, 1955; C - winter wheat, 1957; D - second year grasses, 1958. 1 - total of water-stable aggregates >0.25 mm in diameter %; 2 - aggregates >1 mm in diameter; 3 - soil moisture, %. The dashed line shows the same indices on plots without plants.

oil moisture on plots without plants. High oil moisture corresponds to a low quantity of ater-stable aggregates at harvest time. It clear that plants have a positive role in the eation of a water-stable structure and that is is partly due to drying the soil by its teraction with the root system. After the rvest, when soil moisture normally increases far into the autumn, the structure is estroyed on plots without plants. When anal precipitation is nearly normal the content water-stable aggregates in the soil increases slightly beneath perennial grasses, en within a year of sowing. In 1953, when ecipitation was unusually heavy in the cond half of the growing period (497 mm as ainst a long-term average of 270 mm), structre was also destroyed under perennial asses.

A parallel study of the dynamics of soil ructure on unsown plots and under plants reals the role of the latter in structure foration when the soil is most moist, i. e., in e fall and especially in early spring. The levant data are given in Table 1.

The data in Table 1 show that plants increase e quantity of water-stable aggregates in the il. The water stability of the structure is vered in late fall, winter, and early spring. e agriculturally most valuable aggregates 1 mm in diameter) are more destroyed der vegetation than in the soil of unsown plots (in the fallow field, under winter wheat, undersown with grasses).

The difference to be observed in different years in the change of the structural condition of the soil in the same link of the rotation (fallow — winter crops) is connected with the way in which the soil is wetted in the late fall (before the soil freezes), and in the early spring (before physical maturity). In 1956-1975 after winter wheat undersown with grasses (field IV), the total amount of water-stable aggregates decreased from October 10 to May 5 by 2%, while that of aggregates >1 mm in diameter decreased by 6.7%. In the same link in 1957-1958 (field III), the decrease in water-stable aggregates was 13.9% and 10.9%, respectively. In the first case 63 mm of precipitation fell in the 20 days after the soil samples were taken in the fall, and in the same period before sampling in spring, but the soil moisture when the samples were taken was 20.8% in the autumn, and 22.8% in the spring. In the second case there were 146 mm of precipitation in this interval of time, and the soil moisture was 22.5% and 24.3%, respectively.

Water has a diverse influence on the state of soil structure. Its role in structure formation has been examined in detail by Vilenskiy (3), and Vershinin (2). Here we shall only point to the indirect effect on soil moisture, excess of which leads to inadequate aeration and the development of reduction processes in the soil.

Table 1

Effect of plants on the dynamics of water-stability in the structure of the plowed layer in the late fall, winter, and early spring

Field No. and year	Crop	Quantity of water-stable aggregates > 0.25 mm in diameter in the fall, %				Decrease (-) or increase (+) of water-stable aggregates by the spring of the following year, %			
		Under plants		On areas without plants		Under plants		On areas without plants	
		Total	Of which >1 mm in diam.	Total	Of which >1 mm in diam.	Total	Of which >1 mm in diam.	Total	Of which >1 mm in diam.
III 1956	Black fallow — winter wheat	50,7	14,4	43,0	10,4	—18,7	— 8,4	— 6,1	—2,7
1957	Winter wheat + grasses	56,8	18,0	36,1	6,5	—13,9	—10,9	— 0,7	+0,9
IV 1956	Winter wheat + grasses	51,2	19,8	47,5	12,3	— 2,0	— 6,7	—10,2	—3,5
1957	Second year grasses	46,2	13.7	46,2	13,4	None	— 4,5	— 3,0	—6,8

Note: Soil samples taken on October 10-12 in the fall, and May 5 in the spring.

Note: Comma represents decimal point.

Table 2

Content of mobile iron in the soil in spring, and alteration in water-stability of the structure from late fall to early spring

Field No. and year	Crop	Under plants			On plots without plants		
		Mobile iron, mg/100g of soil	Ferrous iron, % of mobile	Decrease in water-stable aggregates by spring %	Mobile iron, mg/100g of soil	Ferrous iron, % of mobile	Decrease in water-stable aggregates by spring %
III 1956—1957	Fallow — winter wheat	9,5	14,8	— 8,4	8,4	9,5	—2,7
1957—1958	Winter wheat + grasses — second year of grasses	10,5	18,7	—10,9	8,5	11,8	None
IV 1956—1957	Winter wheat + grasses — second year of grasses	9,6	13,6	— 6,7	9,0	8,9	—3,5
1957—1958	Grasses in the second and third year	10,5	11,4	— 4,5	9,0	5,6	—6,8

Note: Comma represents decimal point.

In low calcium (e.g., sod-podzolic) soils iron humates are the main substance that cements the aggregates. If one determines the quantity of iron humate in microaggregates (the material for the formation of macroaggregates) in samples taken for structural analysis in the spring, summer, and fall by Tyulin's method (11), one easily realizes that their seasonal dynamics are directly linked with the quantity of water-stable aggregates determined by the normal method. This connection is most clearly revealed for aggregates >1 mm in diameter (10). Increase in soil moisture in the fall, and especially in the early spring, causes the oxidation-reduction potential to decrease and ferric iron to be converted to ferrous iron. There is partial dispersion of aggregates, owing to the conglomeration of films and gels, consisting of humic matter and sesquioxides (of iron and robably also of aluminum). The quantity of ater-stable aggregates in the soil decreases.

In 1957-1958, available forms of iron were etermined in the soil of the experiment fields the rotation in a sulfuric acid extract with $-\alpha'$ dipyridyl. The results are given in Table

The data in Table 2 show that when the soil excessively wet in spring considerably ore ferrous iron accumulates under vegeta- on than in soil not subjected to the effect of egetation. This accounts for the considerably reater destruction of water-stable structure nder plants in the late fall, winter, and early pring. The conversion of ferric into ferrous on is connected with the biochemical proc- sses of the decomposition of organic matter nder anaerobic conditions.

Conclusions

1. The seasonal dynamics of water-stability soil structure are intimately connected with drothermal conditions and especially with e dynamics of soil moisture. The vital ac- vity of plants has some influence in increas- g the water-stability of soil aggregates. erennial grasses do not have basic advantages er annual crops in this respect.

2. The withdrawal of the effect of plants on e soil after harvest leads to a gradual de- ruction of the structure formed during the owing period. This process is impeded by e addition to the soil of organic matter in the rm of fertilizers (e.g., to potato crops). erennial grasses aid in the retention of the il's structural condition in the fall and in me cases improve it, since they continue to eract with the soil and maintain it in a com- ct condition.

3. Excessive wetting of the soil in the late ll (before freezing), and in the early spring efore physical maturity of the soil) causes e water-stability of the structure to be creased. The soil is simultaneously broken wn -- the quantity of the agriculturally most luable aggregates decreases. This process most clearly seen under vegetation, and e water-stability of the aggregates is less fected from late fall through early spring on il cleared of vegetation.

4. The reduction processes that develop en aeration is insufficient and the activating oducts (applied organic fertilizers, dead ots, and plowed-in stubble residues) present in the soil are one cause of the destruction of an agriculturally valuable structure when the plowing layer is excessively wet.

Received July 13, 1959

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THE ROLE OF FOREST LITTER IN HEAT INSULATION

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We studied the heat insulating capacity of forest litter from different stands in the Komissarov Plantation area (Dnepropetrovsk region) as part of the standing multi-purpose expedition of the Dnepropetrovsk State University. Studies were based on typological principals developed by Bel'gard (1) for planted forests in the steppe zone of the Ukraine. These principles, as is well known, are based on three typological units: 1) the conditions of forest growth, 2) ecological structures, and 3) forest stands.

The type of ecological structure of a forest plantation determines its light structure and the duration of its influence on climatic and soil conditions (1). When laying out plantations the forester should take care to create an ecological structure which will ensure that the forest has the most beneficial effect possible on the initial steppe location. Our studies have shown that forest litter is a structural element of an artificial forest biocoenosis that has a marked effect on ecological conditions in increasing the moisture of the air and the soil.

The scale of this influence depends on the features of the given forest litter formed by the plantation in the biological cycle. In order to study the part played by different litters in heat insulation 14 experimental plots were selected in shady and semi-light plantations on clay loams with varying degrees of wetting. Air temperatures at 2.5 m, at the surface of the l ter, and beneath the litter were measured wit standard thermometers. Soil temperature (a depth of 10 cm) was measured with Savvinov's mercury thermometers. In view of critical r marks by Sukachev (6), Nebol'sin (5), and oth on a certain lack of accuracy in the methods adopted, we repeated the measurements seve times with the greatest care possible under fi conditions. To compare the temperature indi corresponding measurements were made in plantations (with or without litter) and also or adjacent clearings. The depths to which the s were frozen and thawed were determined by Kachinskiy's method (4), by establishing the gree of compaction of the soil, and the prese of ice crystals in it. The measurements wer made once every 2 to 3 weeks throughout 195 1958.

An analysis of Table 1 which gives data fo the three most typical plots, shows that on plantations of shady structure (English oak) o dry clay loam sites with litter 3.1 cm thick averaging a total of 18.8 metric tons/ha, temperature indices tend to decrease in the plantations in the fall by comparison with the clearing. These differences are evened out the onset of winter but a marked difference d velops between the temperature at the surface

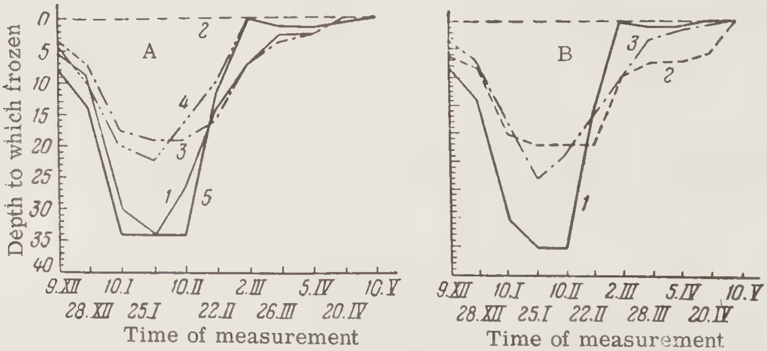

Fig. 1. - Freezing and thawing of the soil (in cm) under the litter of various plantations and in a clearing for the conditions clay loam. (A): the same for the conditions clay loam; clay loam (B).

1 - on the clearing; under litter; 2 - under oak litter; 3 - under white acacia; 4 - under oak-ash; 5 - under ash.

Table 1

Typological formula[a]	Measurement of	Average temperature by seasons								
		Sept., Oct., Nov., 1957			Dec., Jan., Feb., 1957-1958			Mar., Apr., May, June 1958		
		In the plantation		In the clearing	In the plantation		In the clearing	In the plantation		In the clearing
		With litter	Without litter		With litter	Without litter		With litter	Without litter	
$\frac{\text{Ord. ch. c.l.}_{0-1}}{\text{Dark}}$ 10 oak	Air at 2.5 m	+ 7,7	—	+ 8,0	—1,5	—	—1,5	+10,0	—	+11,1
	Surface of litter	+ 9,0	—	+ 8,4	—1,2	—	—1,3	+13,8	—	+15,5
	Beneath litter	+ 6,2	—	—	+0,8	—	—	+ 6,8	—	—
	Soil at a depth of 10 cm	+ 4,9	+5,2	+ 5,7	+0,2	—1,2	—1,2	+ 5,3	+5,9	+ 6,5
$\frac{\text{Ord. ch. c.l.}_{0-1}}{\text{Semi-light}}$ 10acacia	Air at 2.5 m	+12,0	—	+11,7	—0,8	—	—1,0	+19,2	—	+19,2
	Surface of litter	+14,5	—	+12,7	—0,6	—	— 0,8	+16,0	—	+18,2
	Beneath litter	+11,4	—	—	—0,8	—	—	+14,2	—	—
	Soil at a depth of 10 cm	+ 8,5	+7,0	+ 7,2	—0,6	—0,8	—0,8	+12,2	+13,0	+13,0
$\frac{\text{Ord. ch. c.l.}_{1-0}}{\text{Semi-light}}$ 10 Ash	Air at 2.5 m	+10,2	—	+10,2	—1,4	—	—1,4	+13,2	—	+13,2
	Surface of litter	+10,5	—	+10,0	—1,2	—	—1,2	+20,0	—	+16,7
	Beneath litter	+10,5	—	—	—1,0	—	—	+16,6	—	—
	Soil at a depth of 10 cm	+ 8,5	+8,3	+ 8,3	—1,0	—1,0	—1,0	+ 4,0	+6,2	+ 6,2

[a] In A. L. Bel'gard's typology each sector of a planted forest can be described by a typological formula. The numerator describes the conditions of forest growths (dry clay loam ordinary chernozem), the denominator described the ecological structure, and the type of forest stand is indicated at the side.

the litter and beneath it (-1.2°C as against +0.8°C). The soil temperature in the plantation did not fall below zero throughout the winter, whereas on the clearing and on the plot without litter it averaged 1.2°C. In the spring and summer the temperature rises on transition from plantation to clearing. Beneath the litter it is half the surface temperature and almost a third of the temperature in the surface atmospheric layer in the clearing. The soil did not freeze under oak litter in dry conditions (Fig. 1, A), while on the clearing and on the plot cleared of litter the depths of freezing reached 34 cm. It should however be noted that on transition from a dry to a damp or moist location, the part played by oak litter in heat insulation is noticeably reduced and freezing depth of the soil reaches 22 cm as against 40 cm outside the plantation (Fig. 1, B).

The explanation for this is partly that the heat conductivity of the litter and the soil is increased as the degree of moistening rises, and partly that negative relief elements in which cold air masses accumulate form frost-crack locations, as has already been pointed out by Vysotskiy (3).

When analyzing temperature indices on a white acacia plantation (semi-light structure) with litter averaging 3.5 cm thickness and totalling 36.8 metric tons/ha, we found that in the fall, winter, and spring-summer periods there was little difference in the temperature indices for all plots chosen for measurement when compared with the same plots in a clearing, and on plots without litter. The soil was frozen to a depth of 19 cm as against 34 cm in the clearing, and 30 cm on the plot without litter. When we go from dry to damp and moist locations the capacity of the litter for heat insulation was still further lowered and the soil was frozen to a depth of 28 cm as against 19 cm in the plantation in a dry situation. It should be noted that the litter formed by such a well-distributed shrub as the yellow acacia is similar in physical properties to that of the white acacia.

On plantations of European ash (semi-light structure) in which the 0.6 cm thick litter totals 0.360 metric tons/ha on dry clay loams, the differences in the temperature indices by comparison with the clearing are evened out at all seasons. The slight decrease in temperature under the litter in the spring, by comparison with data for the surface layer of the plantation, and the ground level in the clearing is due to the presence of grass residues. The depth to which the soil is frozen under the litter reaches 34 cm, which corresponds with the indices for the clearing. The data show that litters formed in plantations of European ash have very low heat insulation properties.

Conclusions

1. Forest litters play a part in heat insulation both because of their thickness and quantity and especially because of their varied physical features. Thus, despite the fact that the litter of white acacia is almost six times thicker than that of the ash (3.5 cm as against 0.6 cm), and its total amount is more than 100 times greater (36.8 metric tons/ha as against 0.360 metric tons/ha), the heat insulation effect of both litters is extremely similar in its indices.

2. The greatest heat insulation capacity is possessed by the litter of plantations of English oak of shady structure, and the least by the litte of white acacia and European ash of semi-light structure. It must be emphasized that the litter of ash plantations has the lowest heat insulation properties.

3. The heat insulation capacity of oak litter decreases as the amount of European ash in the stand increases, and also in relation to the presence of a yellow acacia underscrub.

4. It has been established that the heat insulating capacity of all litters declines as one passes from dry to moist habitats.

5. Under zonal steppe conditions, where the forester must mainly be concerned with accumulating and retaining moisture, forest litter must be retained and preserved. Plantations must be primarily of shady structure and consi mainly of pure oak that is able to form a slowly decomposing litter with high heat insulation indices to protect the forest soil from overheatin in the summer and from freezing in the winter and, in as far as possible, to convert surface runoff into the deep soil.

Received October 30, 1959

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IOLOGICAL ACTIVITY OF SOILS

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Microbiologists determine the biological ctivity of soils from the content of various hysiological groups of microorganisms, aliough it is known that a part of them is presnt in the soil in an inactive state.

Some investigators (11) consider that the iological activity of soils can be measured by etermining CO_2 production. It is difficult to oncur fully. It is impossible to equate the tensity of CO_2 liberated from the soil, i. e., soil respiration, " with biological activity. espiration may be treated as one of the indices r biological activity in the soil, but it is contioned by the nature of gas exchange between e soil and the atmosphere (7), as well as by ological factors. Soil enzymes have recently een attracting greater attention from biolosts. The most detailed studies of this queson have been made by Hofmann and his coorkers (9, 10), who consider that soil ferlity can be judged from the activity of soil nzymes. Kuprevich (4) has developed similar ews.

Drobnik and Sayfert (2, 3), and Scheffer and wachtmann (12) do not consider that the acvity of soils enzymes is a criterion of the iological activity of soils and especially not il fertility, although they do not deny that ey can serve as subsidiary indices of biologil processes in the soil. Drobnik, who udied the enzymatic activity of forest soils d compared his data with other indices (CO_2 berated, the quantity of microorganisms, trification, and ammonification), did not d any parallelism. He suggests that a ethod involving the use of a respirometer ould be employed to make a more thorough udy of the biochemical conversions of organic atter in the soil, since this enables one to sess the degree of mineralization of the ornic matter from the O_2 consumption (2).

Some authors (5, 8) have found a direct retionship between the activity of enzymes, the mbers of microorganisms, and the amount CO_2 liberated, and consider that these indis can give a picture of soil fertility. Aleksanova (1) has suggested that determination of zyme activity (saccharase and asparaginase) ould be used to reveal the corresponding sily mobilized forms of organic matter that e normally present in the soil in small iounts.

It is clear from this brief review of the main works devoted to the biological activity of soils that the very concept of "the biological activity of soils" is a many-sided and inadequately defined term.

We have studied the enzymatic activity of saccharase and catalase, the intensity of CO_2 liberated, and the nitrification capacity and group composition of microorganisms under various agricultural conditions, and for various types of vegetation for two growing periods on fine clay loam sod-podzolic soils of an experiment field at the Leningrad Agricultural Institute. Some of the plots were selected on an 18 year abandoned land on which the vegetation consisted mainly of variety grasses, and the rest on two plowed plots; ordinary agricultural practices had been employed on one of them (normal soil). In order to effect a rapid improvement in the sod-podzolic soils, the other plot had been plowed to a depth of 38 cm in 1956, the humus horizon and part of the illuvial horizon had been translocated and 80 metric tons/ha of peat and manure (1:1), and 8 metric tons/ha of lime had been applied (rich soil). Both plots had been sown to Diamant winter wheat in 1958. In 1959 there was an oat-pea mixture on the first plot and grasses in the first year of use (clover + timothy) undersown to winter wheat on the second. An area of sod-podzolic fine clay loam covered with dead coniferous forest (Semrino, Leningrad region) was selected for comparison. Samples were taken by layers on these areas in the course of the 1958-1959 growing periods. All determinations were replicated 3-4 times, fresh samples being used.

Saccharase. This enzyme is associated with the hydrolytic decomposition of nitrogen-free organic compounds in the soil. Saccharase activity was determined by Hofmann's iodine method (10). Figure 1-A shows the activity of saccharase at a depth of 0-10 cm and 10-20 cm beneath various types of land in the 1958-1959 growing periods. Saccharase activity was quite insignificant throughout the growing period at 20-30 cm and 30-40 cm. Saccharase activity was highest in both growing periods in the 0-10 cm layer on the abandoned land. It was a little lower in the forest and even lower on the plowed: it was higher on the rich than on the normal plowed land. Both on the abandoned land and in the forest soils, saccharase was only

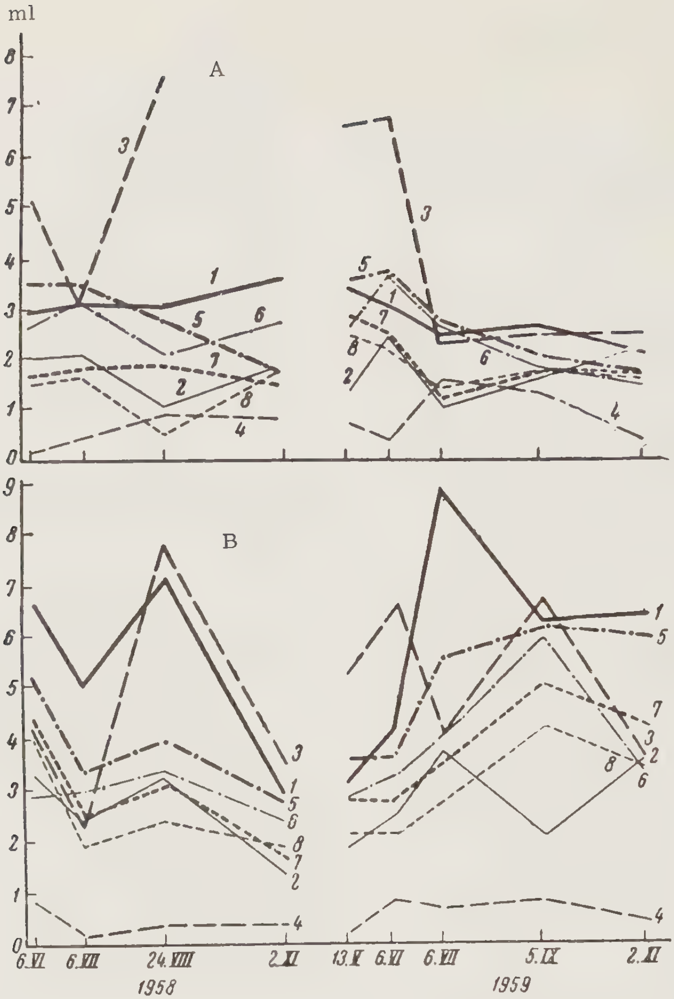

Fig. 1. - Dynamics of catalase activity A (in ml of O_2 for 10 min in 1 g of soil). Dynamics of saccharase B activity (in ml of 0.1 N $Na_2S_2O_3$ per 1 g of soil)

Curves 1 and 2 - abandoned land 0-10 cm and 10-20 cm; curves 3 and 4 - forest 5-13 cm and 13-26 cm; curves 5 and 6 - rich plowed land 0-10 cm and 10-20 cm; curves 7 and 8 - normal plowed land 10-20 cm.

active in the uppermost humus horizon and its activity decreases rapidly with depth. It is clear that saccharase is most active in the horizons that contain the main root mass and the largest amount of microorganisms.

It is clear from Figure 1-A that saccharase activity remains quite dynamic throughout the season. There are two maxima of activity in the spring and towards the end of the growing period. This is explained by seasonality in the processes by which organic residues are decomposed. In the spring there is a lot of easily available organic matter in the soil, the activity of microorganisms is intensified, and hydrolytic processes develop at a great rate. At the beginning of summer the intensity of hydrolytic processes is decreased both owing to the disappearance of easily available organic matter from the soil, and because a number of abiotic compounds that suppress the activity of microorganisms accumulate in it. The new increment of organic matter towards the end of the summer as a result of the dying of the root mass and the cessation of plant growth lea to an intensification of microbiological activity and increased activity of the enzymes.

Catalase is an index of the level of oxidation processes in the soil, since the hydrogen peroxide which it decomposes is formed during th oxidation of protein, carbohydrates, fats, and various other organic substances of the soil. Catalase activity was determined by our own slight modification[1] of Kuprevich's method (4).

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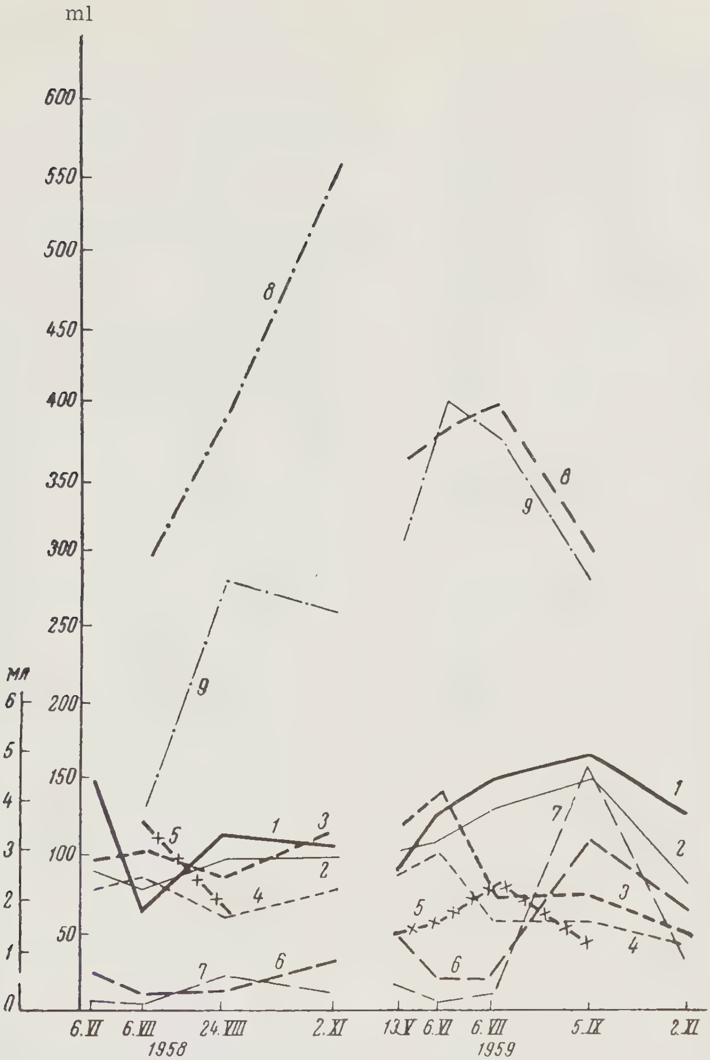

Fig. 2. - The dynamics of catalase and saccharase activity, soil respiration and nitrification capacity on rich plowed land.

Curves 1 and 2 - saccharase (in ml of 0.1 N $Na_2S_2O_3$) 0-10 cm and 10-20 cm; curves 3 and 4 - catalase (in ml of O_2 per 10 min) 0-10 cm and 10-20 cm; curve 5 - CO_2 in kg/ha per hr; curves 6 and 7 - NO_3 (in mg/kg of soil) in fresh samples; curves 8 and 9 - NO_3 after composting 10-20 cm.

gure 1-B shows catalase activity in the soil all experimental treatments in 1958-1959. e activity of catalase, like that of sacchar- e, is quite dynamic: its change is weakest the abandoned land, and most marked in the rest, and on the plowed land. It should be ted that catalase is most active after sac- arase has been most active, i. e., intensive hydrolytic decomposition of organic matter is followed in the soil by biological oxidation.

Soil respiration. The liberated CO_2 by the soil is conventionally known as "soil respiration." This process is due to the respiration of plant roots and microorganisms, to the decomposition of organic residues, and to gas exchange between the soil and the atmosphere. The CO_2 production from the surface of the soil was estimated by Makarov's simplified method (6). Throughout the two growing periods all determinations were carried out between the hours of 11 AM and 3 PM. The temperature in

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oil sterilization, as Kuprevich indicates, does not y suppress catalase activity, and we replaced it by dual heating of the soil at a temperature not ex- ding 350°C.

the 0-5 cm layer, and soil moisture at 0-10 cm and 10-20 cm were calculated at the same time. The 1959 observations showed that the process of CO_2 liberation from the surface of the soil was also very dynamic. Both on the abandoned land and on the plowed land with grasses in the first year of utilization, the maximum amount of CO_2 liberated was at the beginning of July when the grasses were in flower. When data for enzymatic activity and soil respiration were compared, we did not detect any direct relationship. Catalase activity was notably reduced when CO_2 liberated was at its highest. Although the maximum activity of saccharase corresponded to the maximum respiration of the soil, subsequent decrease in the amount of CO_2 liberated was not accompanied by an equally sharp reduction in the activity of this enzyme.

Nitrification capacity. To study nitrification capacity we selected areas from which the vegetation had been systematically removed on all the experimental lands. Catalase and saccharase activity, soil respiration, and nitrification capacity were determined on these areas. At the same time as we determined nitrates in fresh samples, we also determined nitrification capacity under laboratory conditions. Soil samples were composted for 12 days at +12°-+28°C and a moisture of 60% of total water capacity. As an illustration we show in Figure 2 the dynamics of nitrification capacity, and of the accumulation of nitrates in a riched plowed soil. Curves for the dynamics of saccharase and catalase activity, and for the liberation of CO_2 are given for comparison. Both the soil's nitrification capacity and its nitrate content are very dynamic: nevertheless no complete correlation was found to exist between catalase and saccharase activity, CO_2 liberated, the amount of nitrates in the soil, and its nitrification capacity. In the rainy cool summer and dry warm autumn of 1958 the maximum concentration of nitrates in the soil was observed at the beginning of November, while in 1959, which was drier and warmer, the maximum occurred in September. The maximum potential nitrification capacity only coincided with the maximum accumulation of nitrates in the soil in 1958, while in 1959 it occurred in July, whereas nitrates reached their maximum in September. Maximum saccharase activity occurred in the spring in 1958, maximum nitrification capacity in the 0-10 cm layer in November, and in the 10-20 cm layer in August. Maximum catalase activity in this year was recorded in July and November. In 1959, there was a somewhat clearer parallelism between catalase activity and the nitrification capacity of the soil: the maxima occurred in June and the minima in September. No correlation between saccharase activity and nitrification capacity was observed in 1959. It is evident that each of the indices studied reflects a definite biochemical process in the conversion of organic residues in the soil and does not coincide in time with other processes. Similar data were obtained from the other treatments of the experiment.

Some authors note a connection between the enzymatic activity of soils and the quantity of separate groups of microorganisms. Particular importance is possessed by the physiological group of microorganisms which produces the given enzyme in the greatest quantities, or is associated with a given biochemical process in the soil (5, 8). To reveal this connectio we studied the group composition of the microorganisms by the accepted method of culturing them on the corresponding culture media.[2]

The analyses were replicated three times with two dilutions. We shall give data for one of the determination periods for samples take from areas without any plants (removed to exclude the supply of nitrates by plants, and the influence of the root system on enzymatic activity: Table 1). There was great variation, both in the total quantity of microorganisms and in the ratios between the separate groups in the soils of the different land use, and even in different layers of the soil on one type of land use. The largest quantity of microorganisms was found in the soil of the plowed land; there were considerably less in the soil on the abandoned land, and very few in the soil under forest. The dominant group in all the soils except the forest soil was putrefying bacteria, the number of which was especially high in the normal plowland. In the upper layer of the abandoned soil the second place was taken by denitrifyers and molds, an there were also butyric and aerobic cellulose-decomposing bacteria and nitrifiers; in the 10 20 cm layer the next most common form after putrefying bacteria was butyric bacteria. Th were very few molds and nitrifiers. The plow soil contained putrefying bacteria. We also detected a significant quantity of denitrifyers butyric bacteria, and also aerobic cellulose-decomposing and nitrifying bacteria. The latter were found in the largest quantities in the rich plowed land. There were no putrefying bacteria in the forest soil: the upper laye only revealed molds and a large number of nitrifyers, while the 13-26 cm layer contained denitrifyers. The remaining groups of microorganisms were not detected in the forest soi

No very clearly defined correlation was found between the total number of microorganisms or of separate groups, and the indices f biological activity in the majority of cases. Despite the small number of microorganisms in the upper layer of the forest soil, where they were represented only by molds, conside able saccharase and catalase activity was detected. The largest number of microorganisms drawn from all the groups studied was found in the upper layer of the normal plowed soil, although this layer had average values f all the indices of biological activity. If there a correlation between saccharase activity and the development of a mold microflora in the soil of the forest and the abandoned land, this relationship is certainly absent from the rich plowed soil, in which the activity of this enzyme is at its highest: the main saccharase producers in this case are bacteria. It is onl

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[2] Putrefying bacteria on MPA (Meat-peptone-aga molds on Čapek's medium, denitrifying bacteria on Hiltai's medium, nitrifying bacteria on leached aga with ammonium-magnesium salt, cellulose aerobic on Hutchinson's medium, butyric anaerobic on potato purée.

Table 1

Group composition of microorganisms, saccharase, and catalase activity, content of nitrates, CO_2, and nitrification capacity of the soil (July 6, 1959, areas without plants)

Land use	Horizon	Depth, cm	In thousands per 1 g of absolutely dry soil							NO_3 in mg/kg		Saccharase activity, ml of 0.1 N $Na_2S_2O_3$	Catalase activity in ml of O_2 per 10 min	CO_2 in kg per ha for 1 hr
			Molds	Bacteria on MPA	Aerobic cellulose	Anaerobic butyric	Nitrifying	Denitrifying	Total quantity of microorganisms	In fresh samples	After composting	In 1 g of soil		
					Bacteria									
Forest	A_1	5—13	18,3	0,0	0,0	0,0	0,3	0,1	18,7	—	—	4,0	2,38	—
	A_1A_2	13—26	9,27	0,0	0,0	0,0	0,1	42,8	52,2	—	—	0,2	1,6	
Abandoned land	A_1	0—10	15,4	714,0	4,0	10,0	0,9	50,0	793,9	29,0	95,0	3,8	2,62	2,52
		10—20	1,01	703,0	0,0	44,0	1,8	0,0	754,8	17,76	45,0	1,6	1,38	
Rich plowed	A_1	0—10	3,8	1400,0	3,0	19,2	2,3	42,1	1460,4	22,3	400,0	4,6	2,0	2,52
		10—20	4,0	814,0	3,0	46,7	1,7	4,0	873,4	13,1	372,0	3,8	1,76	
Normal plowed	A_1	0—10	2,1	5000,0	2,7	43,7	0,7	37,5	5086,7	13,6	160,0	3,4	1,24	2,0
		10—20	7,5	2340,0	0,0	25,0	0,5	31,2	2364,2	15,7	160,0	2,4	1,3	

Note: Comma represents decimal point.

in isolated cases that data on nitrification capacity agrees with the number of nitrifyers in the soil. Nitrification capacity is at its highest and the number of nitrifyers is greatest in the rich plowed soil. It is evident that data on the group composition of microorganisms obtained by culturing on the media that are most favorable to their development do not reflect the activity level of the microorganisms in the soil in a given observation period. It should also be borne in mind that enzymes retain their activity in the soil after the lysis of microbial cells. Thus, the connection between the group composition of microorganisms in the soil and the separate indices of their biological activity is very complex and still insufficiently clarified.

Conclusions

1. A comparative study of the enzymatic activity of heavy loam sod-podzolic soils in an abandoned land, a forest, and a plowed land shows that periods of maximum saccharase activity are followed by periods of maximum catalase activity.

2. No direct relationship was revealed from a comparison of catalase and saccharase activity with the intensity of CO_2 liberation from the surface of the soil and with its nitrification capacity.

3. It has been established that there is no direct relationship between the activity of the enzymes studied and the numbers of the main groups of microorganisms in the soil.

4. The absence of parallelism between the separate indices that describe the biological activity of soils shows how complex is this concept.

Received December 26, 1959

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ICREASING THE PRODUCTIVITY OF BROWN SOLONETZIC SPOTS A CHERNOZEM COMPLEX

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In the very early stages of the development
soil science leading Russian natural his-
ians noted that burrowing animals and various
ices of their activity (burrows, mounds and
locks) were widely distributed in virgin areas.
us, for example, Vernadskiy (1) noted the
esence of a large number of mounds created
animals on the surface of the soil in the
rmer state Yekaterinoslav: "these mounds
count, on average, for approximately one-
th of the surface of the steppe; but there are
ctors where half the area and almost the
ole surface is covered by such mounds."

When studying the soils of the Konstantino-
ad district and the Donets surrounding, Doku-
yev pointed out that all the large piles of
rth which I saw were found, without excep-
n, to be deluvial clay thrown up to the sur-
e from beneath the chernozem and often
ine. In various places I had occasion to
e that under the influence of atmospheric
ter, and largely as a result of the plowing
r of the ground, these piles of saline clay
re levelled with the surrounding soil to
m a specific saline spot" (4). Pankov (6),
studied the soils of the central chernozem
ion and worked through the literature on
-up chernozems indicated that chernozems
up by moles "occupy considerable areas
he Tambov State, and extend into the Vor-
zh State and on to the Kharkov, and prob-
y also to the Kursk State (no indications in
literature), and to the Chernigov, Kiev,
tava, and other southwestern States."

t would thus appear from the literature
there is quite an extensive region in
ch the soils have been dug up by burrowing
mals and in which, consequently, there are
wn spots in the chernozems.

Despite the wide distribution of these brown
ts and their considerable incidence in
e fields of rotations, there has as yet not
n any study concerned with increasing their
ductivity, and equalizing the fertility of the
le soil complex. The best that can be said
hat some investigators (2, 5, 8, 9, 10, etc.),
e indicated the existence of these soils in
ious rayons or Oblasts', but have not given
detailed physicochemical and agricultural
cription of them.

t was only in 1921 that A. M. Pankov started the study of these soils. He described their morphological features and also gave some physical and chemical studies of dug-up chernozems. In his paper "Burrowing animals and their part in soil formation" Pankov noted: "the conclusions drawn from these observations may be hardly convincing, but I shall be satisfied if this article arouses the interest of workers in this field and compels them to pay considerably more attention than in the past to animals that are concerned in soil formation" (6).

The low productivity of dug-up chernozems (the brown spots of chernozems) and their high percentage distribution call for detailed studies of their nature to establish the main ways in which their productivity can be increased.

The Yelan'-Kolenovskiy beet sovkhoz in the Voronezh Oblast' (the subject of this study) is a typical example of the distribution of brown patches in chernozems. A large number of these spots are to be found here against a general background of chernozem. The area of each individual patch is slight, varying from 20-30 to 100 m², and the total area of brown spots on some fields in the rotations is 15%-50%.

We found that these brown spots in the dark chernozems were plowed-up mounds and burrows of marmots. The brown color of these soils is due to the low humus content caused by mixing the soil mass of the upper and lower layers, and also to the poor steppe vegetation formerly found on the dry hills of the marmot colonies, that did not favor the accumulation of humus. The low humus content accounts for the low content of mineral plant nutrients, and the low productivity of these soils. Low productivity is also, however, due to solonetzization.

When a spotty field is sown with a crop, the crop itself is usually spotty. The plants on the brown spots are stunted and poorly developed and give a low yield.

Field study of the morphological features of brown solonetzic spots in chernozems shows that they have a cinnamon-brownish color from the surface downwards, a shallow humus profile with a scarcely recognizable transition from the humus horizon to the parent material, and that as a rule there are several krotovinas

(3 or more). Since the soil profile has been dug-up in the brown spots, it is difficult to separate the genetic horizons, and it is often impossible to detect the transition from one horizon to another.

A study of the physical properties of brown solonetzic spots in chernozems shows that the structural elements of these soils are friable, irregular, and unstable. Thus, the quantity of water-stable aggregates was 50.70% in the plowing layer of a brown solonetzic spot in a chernozem, and 54.42% in the layer beneath, while the corresponding figures in an ordinary chernozem were 56.68% in the plowed layer, and 69.02% beneath.

Since the brown solonetzic spots are more friable than the surrounding chernozem, their bulk density is less. The upper horizons of these soils are almost twice as permeable to water as the corresponding horizons in chernozems.

Chemical studies revealed that the humus content of these spots relative to that of ordinary chernozems is poor (4.50%-5.78% as against 6.96%-6.86%) as a result of which their total nitrogen content is very small. Their total contents of phosphorus are not greater than those of ordinary chernozems. Their slight adsorption capacity (50.60 meq per 100 g of soil), and the high amount of adsorbed sodium (3.50 meq per 100 g of soil), brings brown spots close to medium solonetzic soil types in Antipov-Karatayev's classification.

In 1956-1958 we set up special experiments on the Yelan'-Kolenovskiy beet sovkhoz in the Voronezh Oblast' to find out why the soils of brown solonetzic spots on a chernozem were of low productivity, and to devise methods for increasing their crop yields. In these experiments different types of fertilizers were applied to seed sugar beet.

The following combinations were selected:

1. rotted manure 20 metric tons/ha + P_{40} + K_{20} + K_{40} kg/ha primary nutrient; 2. rotted manure 20 metric tons/ha without mineral fertilizer; N_{40} + P_{40} + K_{20} kg/ha primary nutrient; 4. first control — the soil of a brown spot without fertilizer; 5. second control — the soil of the normal surrounding chernozem, also without fertilizers.

The fertilizers were only applied to an area of the brown spot in quantities corresponding to 1 m² at the accepted rate per hectare. No fertilizer was applied to the surrounding chernozem.

The dynamics of the water and nutrient regimes of the soil were observed throughout the growing period on 3 experimental areas of each type selected on each experimental plot. The total experimental area was 45 ha, and each experiment plot occupied 3 ha.

The soil moisture observations showed that in 1956, which was a year of average precipitation, the total moisture content in the soil at the beginning of the best growth in the 0-100 cm layer was almost the same in both types o soil (2718-2840 metric tons/ha, except for the brown solonetzic chernozems to which no man had been applied. The amount of water in thes spots was noticeably lower (2608.7-2564.3 metric tons/ha). Although there was a gener decrease in all treatments of the experiment, the same general picture prevailed until the end of July. After this the total moisture con on the experiment plots was equalized. The positive effect of manure in retaining moistur in brown solonetzic chernozem spots is clearl due to improvement in the physical state of th soil and to the high water capacity of the organic fertilizers used.

In 1957, which was a dry year, the entire growing period of the sugar beet was exceedingly arid (there were only 66.7 mm of precip tation between May 1 and September 1 as agai 161.3 mm in 1956). The amount of water in th 0-100 cm layer on the brown spots to which manure had been applied was 100-140 metric tons/ha higher on average than on similar spots without organic fertilizers. In the prolonged absence of rain however the total moisture content on both the manured and the non-manured brown spots decreased relative that in the surrounding chernozem, the difference being 230-350 metric tons/ha.

In 1958, which was an exceedingly wet yea (280.6 mm of precipitation fell between May 1 and September 1 as against 161.3 mm in 1956) the amount of water in the 0-100 cm layer on all the experimental treatments was approximately the same, reaching 2674.2-2921.3 metric tons/ha, except in the surrounding chernozem, where the amount of water in the meter layer was a little lower (2629.4-2771.9 metric tons/ha).

The data on soil moisture content show tha the accumulation of water follows a distinctiv course in the brown solonetzic spots of chernozems. In wet years the brown solonetzic spots are able to accumulate more water than the surrounding chernozem, owing to the considerable looseness of the upper horizons. When, on the other hand, the moisture suppl is inadequate, the brown solonetzic spots give up more water by evaporation than does the chernozem. In periods of drought the moistur loss from evaporation is even greater from the brown spots. At such times they seem to act as "ventilation pipes" through which the air passes rapidly, and in drying out themselves they accelerate the drying of adjacent soil layers. Under these circumstances man in the upper horizon of a brown chernozem sp clearly acts as a "cover" and decreases evap tion of water from the soil.

Observations of the dynamics of available nitrogen content in the soil showed that there were changes in the quantity of adsorbed ammonia and in its dynamics in the different treatments of the experiment. In the first observation periods the highest ammonia content was found in the brown solonetzic spots that had been manured. Thus there were fro 17.7 to 28.09 mg/kg of soil in the 0-20 cm lay in treatments 1 and 2 in May. In the middle of the summer the amount of ammonia in these experimental plots had increased to 25.

/kg of soil in 1956, and 51.69 mg/kg of soil 1957. In the last observation periods the tent of adsorbed ammonia on these plots de- eased.

There is a simple explanation for this be- ior of available ammonia on manured brown onetzic spots in chernozems. The increase mmonia content in May on treatments 1 and s compared with the other plots is associated h manuring. Later, when the manure de- nposes, and also when the soil is sufficiently ist, the amount of ammonia increases.

A small amount of adsorbed ammonia was ected on the plots of surrounding chernozem May (5-9 mg/kg of soil), and in June (10-11 /kg of soil); there was a slight increase later The content of adsorbed ammonia in the wn solonetzic spots of the control chernozems very small (4-8 mg/kg of soil).

In 1958, which was exceedingly wet, the amics of available ammonia content in all experimental plots was, in general, similar hat in the previous years, except for the rounding chernozem plots, where the ount of adsorbed ammonia in the 0-20 cm er was somewhat higher in the first ob- vation period (June 2) than in the soil of anured brown spot (16.10 mg/kg as against -13.41 mg/kg in the soil of the brown spot). level subsequently decreased to 11.62 mg/ f soil as against 20.04 mg/kg and 14.35 kg of soil in the brown spot.

n 1956 and 1957 nitrification followed a e or less similar course in all the experi- tal treatments: in the majority of cases e was an increase in the quantity of ni- es from spring to summer and a decrease ne fall. There was, however, some varia- in the intensity of the nitrification process ne various plots. A rise can be seen in the unt of available nitrogen when one passes n the brown solonetzic spots of the control ne ordinary chernozems and again when one ses to the manured brown solonetzic spots of rnozems.

can be suggested from these data that ncrease in the available nitrogen content e first two treatments of the experiment, n compared with the control, is associated the enhanced activity of soil microorgan- s in the presence of organic matter in the n of humus (rotted).

he low content of available forms of nitrogen ne brown solonetzic spots of chernozems e control plots can be explained by the re- d microbiological activity as a result of oor physical properties of the soil, and e lower contents of moisture and organic er, mainly supplied by soil humus.

1958, unlike the previous years, the quan- f nitrates decreased between the spring he summer and rose slightly again in utumn. The intensity of the nitrifica- process on the various experiment plots similar to that in earlier years. The ation in the course of nitrification in 1958 associated with the rainy cold summer, ich the activity of microorganisms was almost suppressed. It was only when the temperature increased in the autumn and the soil was still sufficiently moist, that microbiological processes in it were able to develop more energetically.

Observations of the dynamics of available phosphorous content revealed a picture that was similar to that of the behavior of mineral forms of nitrogen (ammonia and nitrates), i. e., the non-manured soil of brown spots was also the poorest in these important plant nutrients. When the production of nitrate compounds in chernozems is stepped up it is clear that phosphorous and potassium compounds that are only soluble with difficulty are dissolved, and that this increases their content in the soil solution.

The low availabile phosphorous content in the brown solonetzic spots of the control is also due to the lower microbiological activity in the soil caused by its greater dryness.

It should be noted that the large amount of calcium carbonates in the brown solonetzic spots of chernozems tends to have the same effect, i. e., it helps to convert part of the phosphorus from an available form to one in which it is less available to agricultural crops.

Observations on the content of available potassium did not reveal any fundamental differences between the soils in the different treatments of our experiment, all of which were adequately supplied with this element.

Our crop yield estimates showed that the soil of brown spots has a lower yield than that of the surrounding chernozem. However, the use of fertilizers greatly increases the productivity of this soil and raises the crop yield.

Our data for increased productivity of the soil of brown spots were verified on seed beet and corn, and also on the grain crop that followed the sugar beet — oats. The limits of experimental accuracy were 2.5%-3.7% for the seed beet, 1.8%-4.3% for oats and barley, and 3.4%-3.8% for corn. Data for the seed beet root crop for 3 years of experiments, and for corn for 1 year are given in Tables 1 and 2.

The data in Table 1 show that the effect of fertilizers on soil fertility and on sugar beets varied in relation to weather conditions. In 1956, which was a comparatively wet year in which the sugar beet crop was in general comparatively good, the application of rotted manure (especially when combined with a complete mineral fertilizer) produced a considerable increase on the normal surrounding chernozem (206.5 cntr/ha), and even on the soil of brown spots (181.5 cntr/ha) by comparison with the non-fertilized soil of the brown spot (control 1), and with the soil of the normal chernozem (control 2).

In a year in which moisture conditions were more or less normal, the yield of sugar beets was considerably lower on brown spots without fertilizers than on the soils of the normal surrounding chernozem. When manure and complete mineral fertilizers were applied the yields on the brown spots increased sharply by 98.5-

Table 1

Effect of fertilizers on the soil fertility of brown patches and on the yield of sugar beet roots

Treatment No.	Soil	Fertilizers	Yield, cntr/ha	Increased yield by comparison with the soil of the surrounding chernozem	Increased yield by comparison with the soil of the nonmanured brown soil
		1956 data			
1	Soil of brown spots	Manure, 20 metric tons + N_{40} + P_{40} + K_{20} kg primary nutrient per ha	305,0	$\frac{98,5}{47,6}$[a]	$\frac{123,5}{68,0}$
2	"	Manure, 20 metric tons/ha	240,2	$\frac{33,7}{16,3}$	$\frac{58,7}{32,3}$
3	"	N_{40} + P_{40} + K_{20} kg primary nutrient per ha	177,6	$\frac{-28,9}{-14,0}$	$\frac{-3,9}{-2,2}$
4	"	Without fertilizer (control 1)	181,5	$\frac{-25,0}{-12,1}$	—
5	Soil of normal surrounding chernozem	Without fertilizers (control 2)	206,5	—	$\frac{25,0}{12,1}$
		1957 data			
1	Soil of brown spots	Manure, 20 metric tons + N_{40} + P_{40} + K_{20} kg primary nutrient per ha	128,3	$\frac{-14,5}{-10,2}$	$\frac{32,7}{34,2}$
2	"	Manure, 20 metric tons/ha	134,5	$\frac{-8,3}{-5,8}$	$\frac{38,9}{40,7}$
3	"	N_{40} + P_{40} + K_{20} primary nutrient per ha	97,5	$\frac{-45,3}{-31,7}$	$\frac{1,9}{2,6}$
4	"	Without fertilizers (control 1)	95,6	$\frac{-47,2}{-33,1}$	—
5	Normal surrounding chernozem	Without fertilizers (control 2)	142,8	—	$\frac{+47,2}{33,1}$
		1958 data			
1	Soil of brown spots	Manure, 20 metric tons + N_{40} + P_{40} + K_{20} kg primary nutrient per ha	506,6	$\frac{164,6}{48,1}$	$\frac{175,6}{53,1}$
2	"	Manure, 20 metric tons per ha	457,3	$\frac{115,3}{33,7}$	$\frac{126,3}{38,1}$
3	"	N_{40} + P_{40} + K_{20} kg primary nutrient per ha	384,5	$\frac{42,5}{12,4}$	$\frac{53,5}{16,2}$
4	"	Without fertilizers (control 1)	331,0	$\frac{-11,0}{-3,8}$	—
5	Normal surrounding chernozem	Without fertilizers (control 2)	342,0	—	$\frac{11,0}{3,3}$

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[a] Numerator — cntr per ha; denominator — percentages.

Note: Comma represents decimal point.

123.5 cntr/ha or 47.6%-68%.

A slightly different picture was found in the extremely dry summer of 1957. The sugar be yield was, in general, much lower and the yie on the manured plots were also small. Never

Table 2

Effect of fertilizers on crop after sugar beet

reat- ient No.	Soil	Fertilizers	Grain yield, cntr/ha	Increase in yield by comparison with the soil	
				of the surrounding chernozem	of a non-fertilized brown spot
		1957 - oats			
2	Soil of brown spot	Manure, 20 metric tons/ha	6,2	−0,9[a] −12,7	+0,8 +14,6
4	"	Without fertilizers (control 1)	5,4	−1,7 −24,0	— —
5	Normal chernozem soil	Without fertilizers (control 2)	7,1 —	— —	+1,7 +24,0
		1958 — barley			
1	Soil of brown spot	Manure, 20 metric tons + N_{40} + P_{40} + K_{20} kg primary nutrient per ha	34,8	+3,2 +10,1	+8,7 +33,3
2	"	Manure, 20 metric tons per ha	31,3	−0,3 —	+5,2 +30,0
3	"	N_{40} + P_{40} + K_{20} primary nutrient per ha	28,2	−3,4 −12,1	+2,1 +8,1
4	"	Without fertilizers (control 1)	26,1	−5,5 −21,1	—
5	Normal chernozem soil	Without fertilizers (control 2)	31,6	—	+5,5 +21,1

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[a] Numerator — cntr/ha; denominator — percentages

lote: Comma represents decimal point.

ess, by comparison with the yield from -manured brown spots, the additions from use of fertilizers were considerable, es- ially when manure alone and manure + min- l fertilizers had been used. At the same e the application of fertilizers was not able aise the yield of sugar beet on the brown :s to that obtained from a non-fertilized mal surrounding chernozem. It follows fertilizers are considerably less effective hese soils in drier years.

he fertilizers applied had a great effect he crop after the sugar beet — oats and ey (Table 2).

able 2 shows that even in 1957, which was eedingly dry, the manure applied to sugar in 1956 had a noticeable effect on the yield ne second crop — oats, although it was le to raise the yield of this crop to that ob- ed on the normal chernozem. The increase, omparison with the non-fertilized brown , was approximately 1 cntr per ha, or oximately 15%. The residual effect of ertilizers used was especially great in , which was a wet year (Table 2). The d of barley on the non-fertilized soils of the surrounding normal chernozem (31.6 cntr/ha) and on the soil of brown spots (26.1 cntr/ha) was, in general, quite good, but considerable benefits were noted from the application of rotted manure, especially when combined with a complete mineral fertilizer (Table 2).

Increase in the fertility of brown solonetzic spots in chernozems by the application of fertilizers in the amounts indicated previously is also very efficacious in relation to the green mass of corn, as can be seen from Table 3.

These studies show that comparatively small amounts of manure and mineral fertilizers can fundamentally increase the productivity of brown spots in a chernozem-solonetz complex and the yield of the crops grown on them (first and second crop). In view of the low expenditure of fertilizers when they are selectively applied only to the spots, as in the method tested by us, the fertility of spotty fields is economically increased, especially in wet years. This increase affects both the first and the second crop.

Received May 18, 1959

Table 3

Effect of fertilizers on the yield of green mass of corn, 1958 data

Treatment No.	Soil	Fertilizers	Yield of green mass, cntr/ha	Increase in yield by comparison with the soil	
				of the surrounding chernozem	of non-fertilized brown spot
1	Soil of brown spot	Manure, 20 metric tons + N_{40} + P_{40} + K_{20}, kg primary nutrient per ha	774,0	+281,7[a] +57,2	+352,8 +83,7
2	"	Manure, 20 metric tons/ha	549,0	+57,0 +11,5	+127,8 +30,3
4	"	Without fertilizers (control 1)	421,2	—71,0 —16,9	—
5	Normal surrounding chernozem	Without fertilizers (control 2)	492,3	—	+71,0 +16,9

[a] Numerator — cntr/ha; denominator — percentages

Note: Comma represents decimal point.

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ROCEDURE FOR ESTABLISHING THE CONNECTION TWEEN ATTRIBUTES AND PHENOMENA THAT RE SUBJECT TO SPATIAL VARIATION

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In soil science one often has to indicate the nections between variable soil features and o between different biological phenomena in ls. The usual method used to demonstrate h connections is to prepare statistical maps which these attributes are recorded and to npare them with each other. In particular, s method has been used by V. V. Akimtsev.[1] writes (p. 93): "If one compares statistical ps for the distribution of magnesium in soils g. 1), and cases of cancer of the stomach, he Rostov region (Fig. 2), one will be con- ced that there is an apparent relationship ween the distribution of this disease and the gnesium content of the soils. The incidence ases is lowest in all the eastern districts, re there are mainly chestnut brown solonet- soils rich in magnesium and highest in the rnozem districts, where the content of this ment is lowest."

This purely visual impression of the relation- that exists can be expressed in numeri- form.

We drew a system of dots, situated at the corners of squares, on tracing cloth and gave each point a number. A part of this system is shown in Figure 1. When this transparent stencil was applied to the maps to Akimtsev's article so that each dot coincided with the same location on each map, it yielded the following columns of figures derived from the conventional signs on the charts for the incidence of cancer, and for the quantities of magnesium.

Point No.	Incidence of cancer	Quantity of magnesium
35	I	2
36	I	2
37	II	2
38	II	2
64	I	2
65	I	1 etc.

The Roman numerals denote the level of cancer incidence on the maps: I - low; II - medium; and III - high. The Arabic numerals denote rayons of the Rostov Oblast' as classified by Akimtsev on the basis of the content of water-soluble magnesium in the soils: 1 - 0-0.002% Mg; 2 - 0.002-0.004%; 3 - 0.003-0.005%;

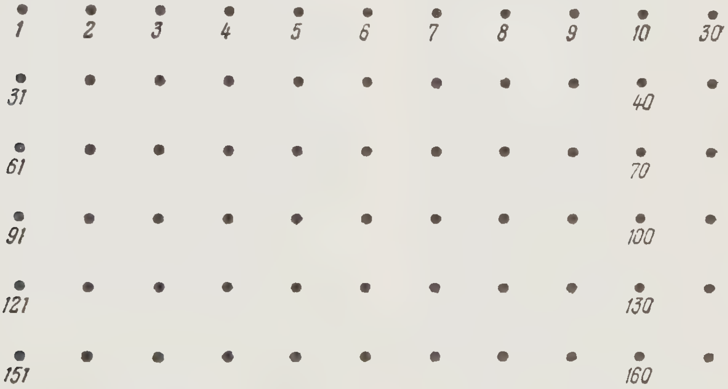

Fig. 1. - Partial diagram of a stencil for reading the features of separate points on statistical maps. It is not necessary to number every point, since they can be calculated from the points which are numbered.

.V. Akimtsev. 1957. Soils and diseases. Poch- deniye, No. 7: 91-98.

and 4 — 0.003-0.030% Mg. We calculated a correlation coefficient of the connection between the cancer conditions of the locality, and the amount of magnesium in the soil. This was found to be 0.1403 ±0.0643. Since this figure exceeds its error by 2.2 times, one can conclude that there is a small negative connection between cancer incidence and the magnesium content in the soil. A chance relationship between the correlation coefficient and its error of this type can only occur once in 35 times, and one can therefore consider that the relationship exists with a degree of certainty that is worthy of attention. If the maps being compared are not drawn to the same scale the points on the stencil for the larger scale map must be spaced correspondingly further apart so that the same points will coincide with the same localities on the maps.

Received March 17, 1960

SE OF A HIGH TEMPERATURE FLAME AND LARGE SAMPLES SPECTRAL ANALYSIS

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The number of microelements is constantly ng added to the chemical elements of inter- to soil scientists and agronomists. When dying microelements in soils, and related terials, one can find the order of their ncentration and give a quantitative descrip- n of soils and other objects from their total croelement content; one can also study the croelement forms and this is the most funda- ntal and difficult problem. These studies quire highly sensitive and acurate methods.

There are special difficulties in the use of ectral analysis methods in soil science and ricultural chemistry. The main difficulty that the content of the elements to be de- rmined in soils, soil extracts of all types, utions, waters, plants, and other materials, often close to or below the absolute sensi- ity of the spectral method. When the spectral ensities of the elements being determined are ry low one encounters the masking effect of spectrum of other elements, of the back- ound, and of bands.

At the present time spectral methods are lacking in absolute sensitivity and accuracy be anywhere near satisfying the require- nts of soil and agricultural chemical analysis. s therefore of great importance to increase absolute sensitivity of spectral methods soil analysis. Chemical, electrochemical physical methods are currently used to ncentrate the test sample (1, 2, 3, 4). In the ysical method, which is simplest and quick- , the elements being determined are first racted from the sample by volatilization and ndensation on a cooled electrode. But this thod is not sufficiently positive when applied soil analysis since the soil sample is a com- cated chemical system. When, therefore, ample is heated in a graphite crucible the ed state is reached at comparatively low peratures and it is volatilized and con- sed on an auxiliary electrode. Fractional atilization becomes quite involved under se conditions.

It has been shown previously that in soil, especially in chemical studies, there is eater interest in determining the forms of iven element, which are first extracted m the test samples, than in determining total content. In this operation the content he element in the resultant solution is lowered both absolutely and relatively when compared with the initial sample, since only a certain part of the element being determined is extracted and the total weight (volume) of the resultant extract is increased. It follows that we need direct spectral methods for the analysis of solutions.

Flame photometry meets the requirements of soil scientists and agricultural chemists for the determination of potassium, sodium, and calcium in relation to both sensitivity and accuracy. These elements do not, however, exhaust the scope of the flame method of spectrum production, which can be extended by using a high temperature flame, by increasing the sample (volume), and by using spectrophotometers and spectrographs with quartz and glass optics. The flame is highly stable in operation and is not dependent on the composition of the sample. When solutions are being analyzed the flow of the sample is extremely regular and is continuously renewed. These conditions provide a satisfactory basis for the elaboration of quantitative determination for a number of elements.

Special burners and sprayers (atomizers) are needed if one is using high temperature flames and large samples (volumes) for analysis. Modifications of this equipment will be described below. Figure 1 shows a burner-atomizer for the injection of solutions into a hydrogen-oxygen flame (2700°C). Oxygen entering through a branch tube (1) draws the solution being analyzed up the vertical tube (3) from the crucible (4) when it passes out through a circular aperture in the nozzle (2). Hydrogen enters through a side tube (5) and passes out through a circular aperture (6). The hydrogen and oxygen are mixed on outlet to form the fuel mixture. If necessary the burner can be water-cooled, the water passing through the side tubes (7) and (8). The use of a burner-atomizer of this type, and a hydrogen-oxygen flame, increases the sensitivity with which certain elements can be determined by more than the order of their concentration by comparison with the atomizers in normal use and an acetylene-air flame. This increase in sensitivity is due to the larger amount of solution entering the flame and the greater temperature of the flame. The burner-atomizer can be used for flame photometry and spectrophotometry.

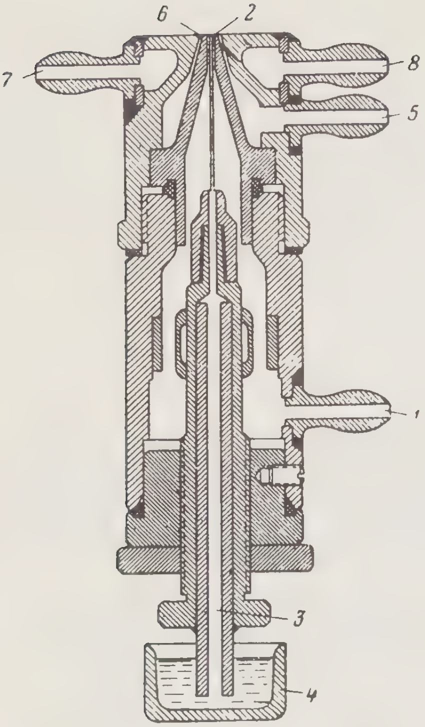


Fig. 1. - Diagram of burner-atomizer for injecting solutions into a hydrogen-oxygen flame (key in text).

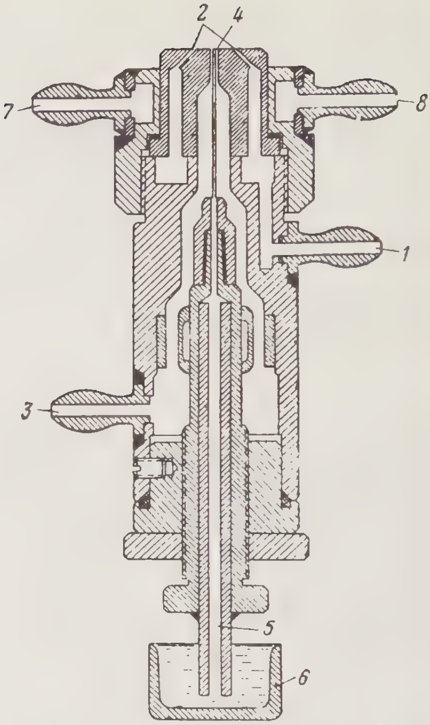


Fig. 2. - Diagram of burner-atomizer for injecting a solution into an acetylene-oxygen flame (key in text).

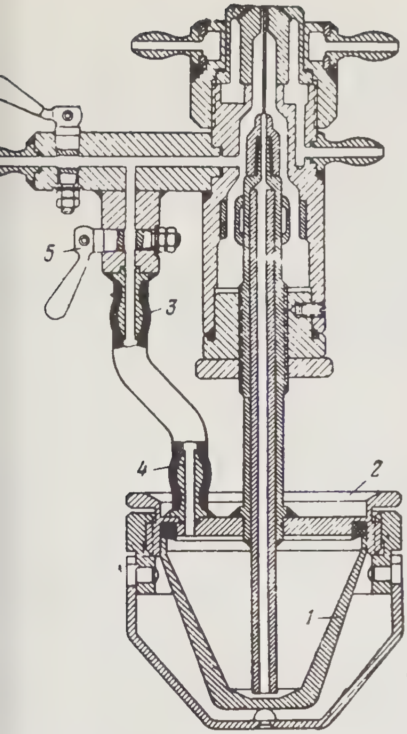
Figure 2 shows a burner-atomizer for injecting a solution into an acetylene-oxygen flame (≃ 3000°C). Here combustion and the entry of the solution are independently effected. The fuel mixture enters through a side tube (1) and escapes through inclined passages in the nozzle (2). Air or oxygen, which enters through a side tube (3) draws the solution up a vertical tube (5) from a crucible (6) and atomizes it through a circular aperture (4) in the nozzle. Cooling water enters and leaves through side tubes (7) and (8).

The angle of inclination of the fuel mixture passages relative to the axis of the burner is 45°-30°. This angle ensures that the atomized solution is blended with the fuel mixture and thus increases the emission strength of the elements. If the angle of inclination is increased it is more difficult to atomize the solution since gas pressure is increased over the escape apertures. If the angle is decreased, emission strength is reduced. Hydrogen-oxygen, propane-oxygen, and other fuel mixtures can be used if the diameter of the inclined escape passages is increased.

Figure 3 shows a burner-atomizer for use with an acetylene-oxygen flame and a pressure feed for the solution. Pressure feeding is essential if the viscosity and density of the solutions being analyzed is high. The solution is poured into a glass (1) which is hermetically sealed to the stand (2) by a removable clamp. The pressure feed is produced by the presence of air or oxygen entering through side tubes (3) and (4) joined by a connecting tube. The feeding of the solution into the flame is regulated by a stopcock (5). Other details are the same as in the preceding example. If more than 10 ml/min of solution are fed into the flame, the solution escapes from the flame zone.

Figure 4 shows a burner-blower for feeding finely-ground samples into an acetylene-oxyge gas-oxygen, or acetylene-air flame. The acetylene-air mixture enters through a branch pipe (1) and escapes through inclined passages (2). The sample being analyzed is poured into the channel of a disc (3), which is rotated by a handle (4). Air or oxygen entering through a side tube (5) take the sample from the meshed base of the revolving disc and carry it to the flame. When working with a gas-oxygen flame the gas enters through a side tube (6) and the oxygen through (5). In this case the fuel mixture carries the sample to the flame. With an acetylene-air flame, the acetylene enters at (6) and the air at (5). The groove channel of the disc has a volume of approximately 20 cm³ and it is therefore possible to use large samples or to charge the groove with several samples if dividing fins are placed in the groove. Two methods are used to charge the groove:

1. The hopper (7) is charged when the stop



g. 3. - Diagram of burner-atomizer for se with an acetylene-oxygen flame and ressure feed of the solutions (key in text).

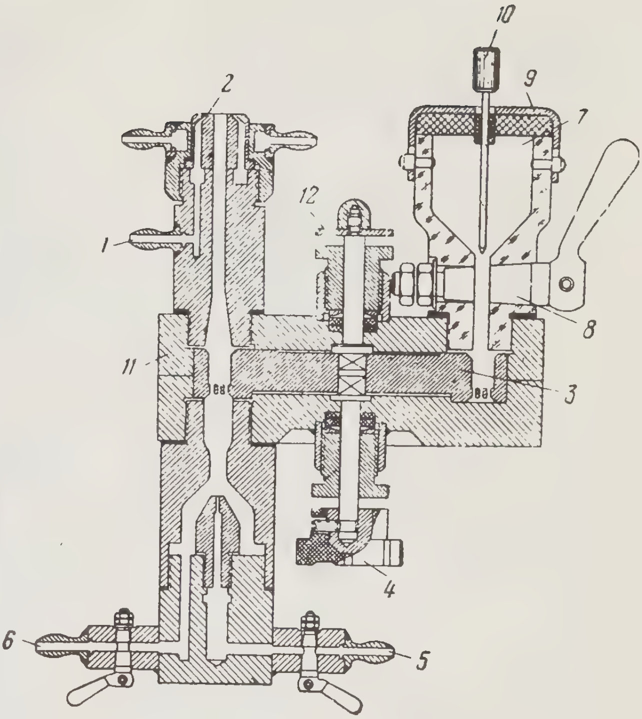


Fig. 4. - Diagram of burner-blower (key in text).

Table 1

nsitivity of determination of some elements

ement	Sensitivity, %	Element	Sensitivity, %
Ag	$5 \cdot 10^{-5}$	Tl	$5 \cdot 10^{-5}$
Sr	$5 \cdot 10^{-5}$	Cr	$1 \cdot 10^{-4}$
Mn	$1 \cdot 10^{-4}$	Ni	$2 \cdot 10^{-4}$
Ga	$1 \cdot 10^{-4}$	Co	$5 \cdot 10^{-4}$
In	$1 \cdot 10^{-4}$	Cu	$5 \cdot 10^{-5}$

k (8) is closed. The cover (9) is fixed in ition, the stopcock (8) is opened, and the dle (10) is agitated, and the disc revolved.

2. The upper part of the burner casing (11) emoved, the sample (one or more) is inluced into the groove in the disc, and the ing is replaced and secured by the reing bolts. The disc is set in motion and trolled from the indicator (12) on the upper t of the casing.

t was found in practice that when the iple was pressure fed with oxygen the ctral intensity in the acetylene-oxygen flame was no higher than when air was used for feeding. A 10-15 g sample can be used up in 2 minutes. If the exposure is less than 2 minutes the sample will not be adequately used. Spectral intensity is not increased if the exposure time is lengthened, but the background (band) intensity on the photographic plate is greater. Spectral intensity is enhanced for the same exposure time if the size of the sample is increased. The absolute sensitivity in the determination of certain elements is in practice the same when they are injected into an acetylene-oxygen flame as solutions or as finely-ground powders. The results are given in Table 1 (artificial mixtures and a medium dispersion spectrograph).

These data show that the use of an acetylene-oxygen flame and large samples or volumes of the samples can markedly increase the sensitivity with which certain elements are determined, by comparison with an an acetylene-air flame. It is as sensitive, or more sensitive, than determination with an electric arc, and some of the positive features of a flame as a source of spectral production are retained. High temperature flames and the methods here described can be used for the qualitative and quantitative analysis of soils and related materials. This will be the subject of a subsequent communication.

Received February 16, 1960

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OIL MOISTURE DETERMINATION BY THE METHOD F NUCLEAR MAGNETIC RESONANCE

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The existing methods for determining soil oisture are all very imperfect. The old ethod of drying samples to a constant weight still the most common. This method is quite curate but it takes a long time. Many ef- rts have therefore been made to perfect a tter method. Recently, for example, vari- s electrometric methods have been proposed r the determination of soil moisture from ectric conductivity or the dielectric constant the soil samples. The main obstacle to e use of this method is that the dielectric nstant and the electric conductivity of the il are also related to the content of salts d organic matter and to the soil structure. ese factors therefore affect instrument read- s based on the use of these methods.

Neutrons and gamma-rays can also be used determine soil moisture, but recent instru- ents with radioactive sources have still not en perfected and can, in the main, only be ed under field conditions, where the soil mples tested are of very large dimensions. us, there is still no solution to the problem measuring soil moisture and new methods st therefore be devised.

The use under laboratory conditions of vari- s spectral methods is of considerable inter- . Owing to their great sensitivity these thods should enable one to determine the con- t of a given component of the sample irre- ctive of its chemical composition. One such oup of methods involves the use of radio- ectroscopy.

Radiospectroscopy is one of the youngest nches of knowledge, the first work in this ld appeared in 1947 (2, 5). This science since been the subject of intensive develop- nt and there are many references in both the iet and the foreign journal literature (1, 5, 2, 19). Several detailed works on radio- ectroscopy have also been published (3, 4, 10, .

Radiospectroscopy is concerned with the dy of the spectra of molecules, free radi- s, and atoms in the radio-frequency range, marily in the meter, centimeter, and milli- ter wave bands. These spectra are studied h an accuracy that is beyond the reach of ical and infrared spectroscopy.

There is a vast scope for the application of radioscpectroscopy. It is used to study the structure of solids and liquids and the individual properties of molecules, atoms, and nuclei. Spectral lines in the ultrasonic frequency range are used in radio engineering as frequency standards for the frequency control of generators. These lines can also be used as time standards in extremely precise atomic and molecular clocks.

Radiospectroscopic observations in astronomy enable one to determine accurately the temperature of the sun and other clestial bodies, and to study the nature of sun spots, etc. Radioscpectroscopy is also used in chemistry to analyze chemical composition, to trace the course of chemical reactions, and also in isotopic analysis. One of the methods of radiospectroscopy, that of nuclear magnetic resonance, can be used both to solve various analytical problems, and also to determine the concentration of hydrogen nuclei or moisture content in a substance.

Experiments have been conducted in the biophysics laboratory of the All-Union Institute for Plant Protection to find out whether it is possible to use the method of nuclear magnetic resonance to determine free moisture content in soils. The principle on which this method is based is that of determination of the resonance absorption spectrum of high frequency energy by the nuclei of hydrogen or by protons.

The test samples were placed in small 1 x 3 cm glass ampoules and the ampoules were inserted in a wire spiral between the poles of a powerful electromagnet. The ends of the spiral were included in a circuit connected to a high-frequency generator working in the meter radio wave band. Thus, during the experiment the sample was simultaneously exposed to the influence of the magnetic field of the electromagnet, and to the high frequency field created around the spiral by its connection to the high frequency generator.

The water in the soil samples contains hydrogen nuclei (protons) which behave in a magnetic field like elementary magnets and process in this field, which has a variable component. The high frequency field formed around the spiral at a given frequency $\underline{f}_0$, which is the resonance frequency for hydrogen nuclei, causes the latter to be reorientated. This reorientation of the hydrogen nuclei is accompanied by the absorption of high frequency energy which is directly proportional to the concentration of hydrogen nuclei in the sample.

The high energy spectral absorption line can be observed on a cathode ray oscillograph incorporated in the set-up. The height of the absorption line is a measure of the content of hydrogen nuclei in the sample. When samples are of equal volume these lines are an index of their percentage content of free moisture. Hydrogen nuclei present in other chemical compounds (e. g., in hydrocarbons), and also in chemically bound water, give a spectral picture that is quite different from the absorption spectrum of free moisture.

Normal gravimetric determination showed that the moisture of the soil samples being tested varied. Figure 1, a, b, c, d, e, shows photographs of the oscillograph screen taken during the determination of moisture by the nuclear magnetic resonance method in a podzolized sandy loam in which the moisture content varied.

These pictures show a marked difference from sample to sample in the height of the line for the resonance absorption of high frequency energy by hydrogen nuclei. Since the difference in the height of the peaks can be seen very clearly, one can determine the moisture percentage with sufficient accuracy.

Mean values for the absorption line of sam ples with various moisture contents were constructed from 40 tests. A moisture content of 11% corresponded to a height of the resonance absorption peak of 17; other figure were 18%-31%; 32%-58%; 55%-93%.

These data are graphed in Figure 2, where the soil moisture is plotted along the x-axis, and the height of the resonance on the y-axis.

It can be seen from Figure 2 that it is diffi cult to determine moisture at below 10% and impossible at below 5%. Therefore, the syst was modified to increase the range of moistur measurements.

These data are graphed in Figure 3, from which it can be seen that the method can be used to determine a moisture content of between 2% and 50%. A 1% change in soil mois ture alters the height of the absorption line by approximately 2 mm. The height of the absor tion line on the photograph can be measured with an error not exceeding 1 mm by the use of a graduated ruler and dividers. The appro imate error in the measurement of moisture by the nuclear magnetic resonance method is therefore of the order to 0.5%-1%.

One can simplify the reading of the height the resonance absorption peak by making it

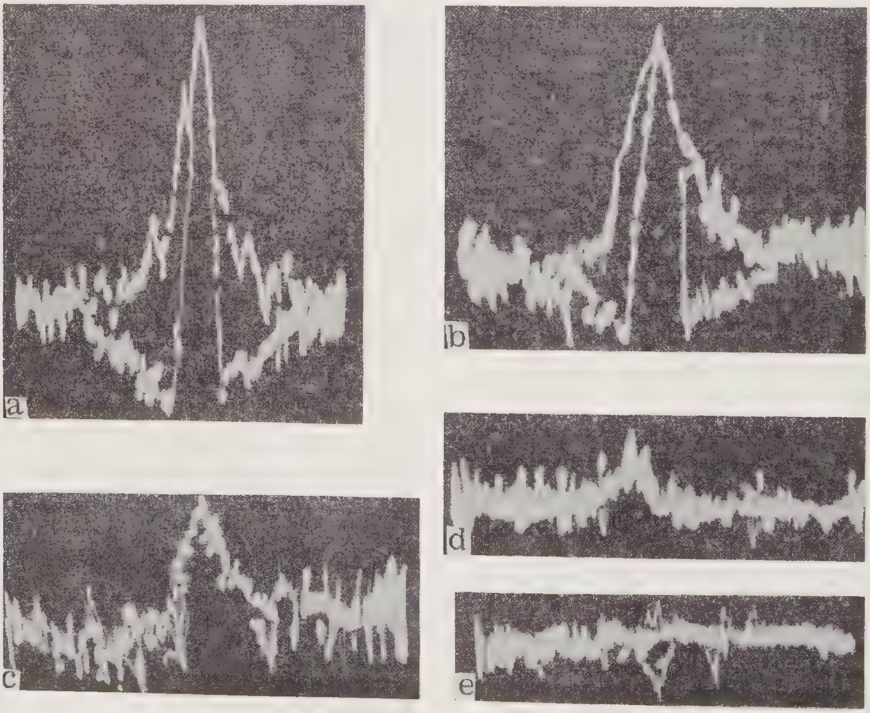
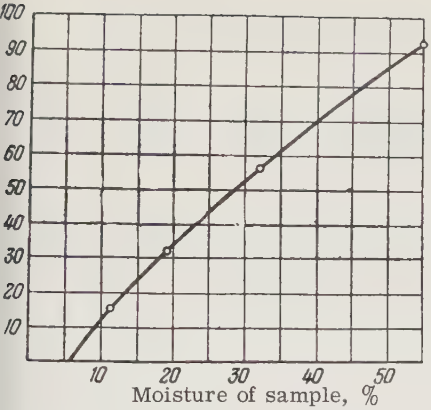
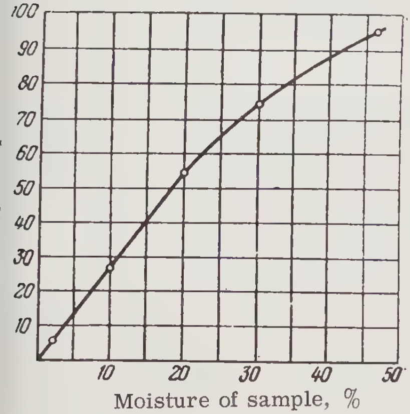


Fig. 1. - Photographs of the oscillograph screen for a podzolized sandy loam of varying moisture.
a - sample 5, 55% moisture; b - sample 8, 32%; c - sample 12, 18%; d - sample 13, 11%; 3 - sample 4, 0%.



ig. 2. - Relationship of the height of the absorption resonance peak to the moisture of the sample.



ig. 3. - Relationship of the height of the absorption resonance peak to the moisture of the sample (low moisture content).

ide in Figure 3 with a scale grid simi-
that normally used on the screen of a
de ray oscillograph. The incorporation
alvonometer parallel to the oscillograph
derably increases the accuracy of mea-
nent. The method can be used for the
control of samples under laboratory con-
s, the measurement time required for
the photographic or the visual method
less than a minute.

this one has to add the time spent in
ring the sample and inserting it in the
atus. This can also be shortened to a
inutes if one has some simple equipment
it is not difficult to construct.

e method proposed thus has considerable
tages over the gravimetric method,
it greatly reduces the time involved;
the point of view of accuracy it is much
accurate than the electrometric methods
mal use (e. g., determination of moisture from the dielectric constant or from electric resistance).

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CHRONICLE

G. VILENSKIY (JULY 1, 1892—FEBRUARY 13, 1960)

G. VILENSKIY,

Professor Dmitriy Germogenovich Vilen- y died on February 13, 1960 in the 68th year. the time of his death he was the head of soil geography faculty in Moscow State versity, and a Corresponding Member of Czechoslovak Agricultural Academy.

Vilenskiy was born on July 1, 1892 at petovka in the Ukraine: after graduation 917 from the agricultural department of the v Polytechnic as an agronomist, he taught he Saratov Agricultural Institute until 1. From 1921 through 1924 he was an istant and docent in the faculty of botany general agriculture in the Tbilisi Polytech- ; from 1924 through 1930 he was a profes- and head of the faculty of agricultural botany he Kharkov Agricultural Institute; from 0 through 1933 he was a professor and d of the soil science faculty at the Kiev romelioration Institute. In 1933 Vilenskiy appointed a professor of the Moscow State versity and from 1940 until his death he ded the faculty of soil geography which he up there.

ilenskiy began his research work in 1915 e Krasnokutskaya agricultural experi- t station.

ilenskiy was a famous research worker, published 195 works. His book *Soil Science* one of the most important works. He did a t deal to assemble new facts and achieve- ts in soil science, which were handled tively so as to develop progressive ideas grobiology. His book *Soil Science* has run ugh three editions in the USSR, two in ese in Pekin, and one in German in in. The book is highly regarded both in JSSR and abroad — it is used as a text- by university and technical high school ents, and as a valued reference work by ialists.

1921-1924 Vilenskiy developed a theory e origin of solonetzes and solonetzic in relation to the history of the Quater- period; he studied the distribution of soils and laid the foundations for their oration by organizing the first extensive es at research stations in the southern ine. His works on the genesis and oration of solonetzes achieved deserved larity in the USSR and abroad. Vilenskiy headed important expeditions (to the Dnieper, the Don, the Terek, etc.) including some to districts with saline soils. Since he was one of the great experts on the soils of the USSR and had extensive (45 years) research experience, Vilenskiy was in continual demand as a consultant and expert, or for assistance in the construction and utilization of large-scale irrigation projects in the areas of the Dneprostroy, Kakhovka, the Volga-Don Canal, the Kuybyshev Power Plant, etc.

He directed research on the soils of the USSR in the Ukraine, the Caucasus, Transcaucasia, and the Tien-Shan, and important research on the soils of State Crop Testing Farms. He directed the work of 15 institutes of higher education on the regionalization of the USSR soils.

Vilenskiy added much to soil classification: his original soil classification based on genetic subtypes in the development of the soil-forming process led to a search for hitherto undescribed soil groups. This classification aroused great interest both in the USSR and abroad, and was translated into English in the United States. He studied the soils of the United States and of Western and Eastern Europe, and published the first genetic soil maps of North and South America, in addition to maps of the People's Democracies and China and a world soil map.

Vilenskiy's work contributed a great deal that was new and useful to the study of soil structure and the nature of physical maturity of the soil: he devised new methods and designed new instruments to study structure, which plays such an important part in soil fertility.

He contributed much to the history of soil science. His book *The history of soil science in Russia* (1958) was the first major work on the history of the science in Russia in which Russian leadership was established; in this connection his work *The Russian school of soil mapping and its influence on the development of world cartography*, and other writings on the history of Russian science were of great importance.

Vilenskiy was a brilliant teacher who trained several generations of agronomists, soil scientists, meliorators, and forestry experts in the course of his 43 years of teaching; thousands of students and specialists have learned and continue to learn from his textbooks (he wrote four). Some of his under-graduate and post-graduate students have since become leading specialists, professors, and scholars.

All his activity was bound up with agricultural practice, with the solution of important economic problems, and with the training of cadres.

From 1934 through 1939 Vilenskiy was the Editor-in-Chief of *Pochvovedeniye* and he served on the editorial board for 25 years; he was Dean of the geology and soil faculty of the Moscow State University for 10 years. He also carried out a great deal of Party and trade union work in the university and in the Central Committee of the trade unions for higher education.

In 1940 Vilenskiy was awarded the order "Mark of Respect." He also received two medals.

Vilenskiy took an active part in the work of the International Society of Soil Science: in 1928 he attended the First International Congress of Soil Science in Washington as a Soviet
delegate; from 1928 to 1930 he did a great dea
of work as the General Secretary of the Organization Committee for the Second Congres
which was held in 1930 in Moscow and Leningrad; in 1939 he attended the International
Congress of Soil Science in Prague, and visit
Germany, Czechoslovakia, and Hungary; in
1930 he was elected as Secretary of the International Commission on soil classification,
cartography, and geography, and in the same
year was elected to membership of the Ameri
can Geographical Society; in 1933 he was elec
Deputy-President of the Soviet section of the
in 1934 he attended the International Conferen
on soil physics at Versailles in France, and
was elected Soviet representative to the International Commission on scientific terminolog
in soil physics. In August 1935 he was electe
Vice-President of the solonetz commission of
the ISS at its Congress in Oxford, and in Dece
ber 1935 was selected President of the Intern
tional Commission of the ISS on soil classific
tion, cartography, and geography. In 1947
he was elected a Corresponding Member of th
Czechoslovak Agricultural Academy.

Vilenskiy was a prominent Soviet scientist who contributed much to the development of soil science and to the training of specialists; he will long be remembered.

ROFESSOR D.G. VILENSKIY'S MAIN SCIENTIFIC WORKS ONCERNED WITH SOIL SCIENCE[1]

S. SOBOLEV

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ilenskiy also wrote articles on botanical ques-
, 32 articles on soil terms published in the Great
t Encyclopaedia, and 10 articles in the agricul-
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